ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA (ICAI)

INGENIERO INDUSTRIAL

Control de Energía - Siemens

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Abstract

In today's world, our buildings need to be more sustainable and efficient. Without the proper tools to advance building sustainability and efficiency, our current life style is not supportable. With the proposed virtual simulator we are able to replicate a building environment with high fidelity. Using a virtual environment, development time for new technologies will be reduced due to the rapid changes the simulator can implement. Additionally, the turnaround time in the training of maintenance staff can be rapid. Our simulator will allow the staff to practice operating the systems faster and more efficiently.

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1. Context

1.1. Background of Need

The Building Technologies Division of Siemens deals with developing intelligent systems that efficiently manage a building in the effort to increase sustainability and efficiency. Currently, buildings in the U.S. use 40.2% of all energy consumed in our society and 73.2% of all electricity (2008). With limited resources, buildings represent an area where massive improvements can be made to the sustainability of our society.

The problem we face is the large amount of energy that is being wasted in these buildings. Siemens has developed a solution to this problem by developing an intelligent energy control system. It is desirable to concentrate resources into creating efficient and creative ways to manage the consumption of energy in today's buildings. We can have an impact with our senior project by building a simulator of a buildings HVAC system that gives students and maintenance staff the opportunity to learn about the Siemens system and how to implement the system to realize more sustainable buildings. This system will turn on and off the different types of energy (light, air conditioning, heating, etc.) using a sensor-based system.

There are several key components to this system that must be replicated in order to have a valid simulator. First, to accurately represent a buildings HVAC system, one needs to replicate the structure of a building. This includes air ducts, heating/cooling elements, sensors, and many more components that are instrumental to the functioning of an HVAC system.

Another key factor is the portability of the simulator system for training technicians. Maintenance has to go to training sites in order to learn about their systems, which in turn causes inefficiencies and cost.

Additionally there is the lack of automation in testing these environments. This also increases cost due to more labor, more time required to test, and inherent variability between tests. The current methods for testing these controls systems are restricting and are not cost efficient.

1.2. Customer Need Statement

Siemens and the U. of San Diego (USD) facilities team have a partnership regarding the HVAC systems on the USD campus. In an attempt to further this partnership Siemens has agreed to provide components to build an environment simulator using their product line. Facilities, as a costumer of Siemens, will be able to use this simulator in order to teach its employees about the HVAC systems used on campus. As this simulator will be a full size mockup, it will accurately portray the direct effects of a HVAC system. The simulator will further show the inner workings of the system that can be visibly seen by the user.

1.3. Literature Review

"If I have seen further, it is by standing on the shoulders of giants." Isaac Newton, 1676

1.3.1. Prior Work

The concept stems from the physical application of a test system where a scaled down system was implemented to demonstrate and test the HVAC system. However, these physical implementations are not portable and require a substantial amount of material and energy to operate. Seeing this need Siemens hired a company to develop a system even further miniaturized and more digitized. This system is semi portable, much more user friendly, and is more efficient to run and build. However, there are a few flaws with this system. It still must be taught in house by Siemens and the user interface is still very limited. On top of this, the Siemens system is not able to run scenarios. The Siemens system must be manually changed by the user. It also still uses a physical implementation of the HVAC system and is only compatible with the Siemens' HVAC system.

1.3.2. Patents

Since our simulator is not a patentable item, but a technology demonstrator, there are no patents for this system.

1.3.3. Codes and Standards

The standards used for the system are those created by Siemens. The main document containing these guidelines is the Apogee Wiring Guideline document. A summary of this document is attached in Appendices 8.7.

2. Problem definition

“Let him that would move the world first move himself.”

-Socrates

2.1. Customer Requirements

- CR1: Build a virtual/physical HVAC system simulator
- CR2: Integrate the simulator with Siemens building control equipment and environment
- CR3: Design a Basic based program to simulate integrated building functions
- CR4: Demonstrate the program, simulator, and Siemens equipment functions seamlessly

2.1.1 Physical Requirements

The physical nature of the simulator needs to be user friendly and extensible.

2.1.2. Functional Requirements

- Simulate an HVAC system
- Real time and rapid response
- User must be able to interface with the system
- System must be user friendly
- System must be intuitive
- System must be extensible
- We want to think ahead for future growth of the product
- We want the system to be isolated from contact
- System must be physically secure and stable
- System must be aesthetically pleasing
- System should have colorful presentation to highlight various functions
- Maintain the functionality of a standard HVAC system on a small scale
- The system should be cost friendly
- The system should be easy to reproduce
- The system should be reliable

- Automated testing

2.2. Assumptions

- We assume that we will have a power source for the system
- We assume the HVAC system will not radically change in the next few years
- We assume that the operator of the Siemens building control systems has basic training with the system
- We will only have access to 120VAC 60Hz power
- We will not have continual access to water to simulate AC
- Not concerned about weight

2.3. Constraints

- We only have one Siemens building control system
- Limited user inputs for simulator
- The project must be finished in 7 months
- Complexity of the design must be within limits of design team
- Physical assembly will be simple
- Simulator must run at room temperature
- Costs not to exceed $1,500
- Weekly contact with Industry advisor

3. Design Specifications

"Innovation has nothing to do with how many R&D dollars you have. When Apple came up with the Mac, IBM was spending at least 100 times more on R&D. It's not about money. It's about the people you have, how you're led, and how much you get it." Steve Jobs

3.1. Design Overview

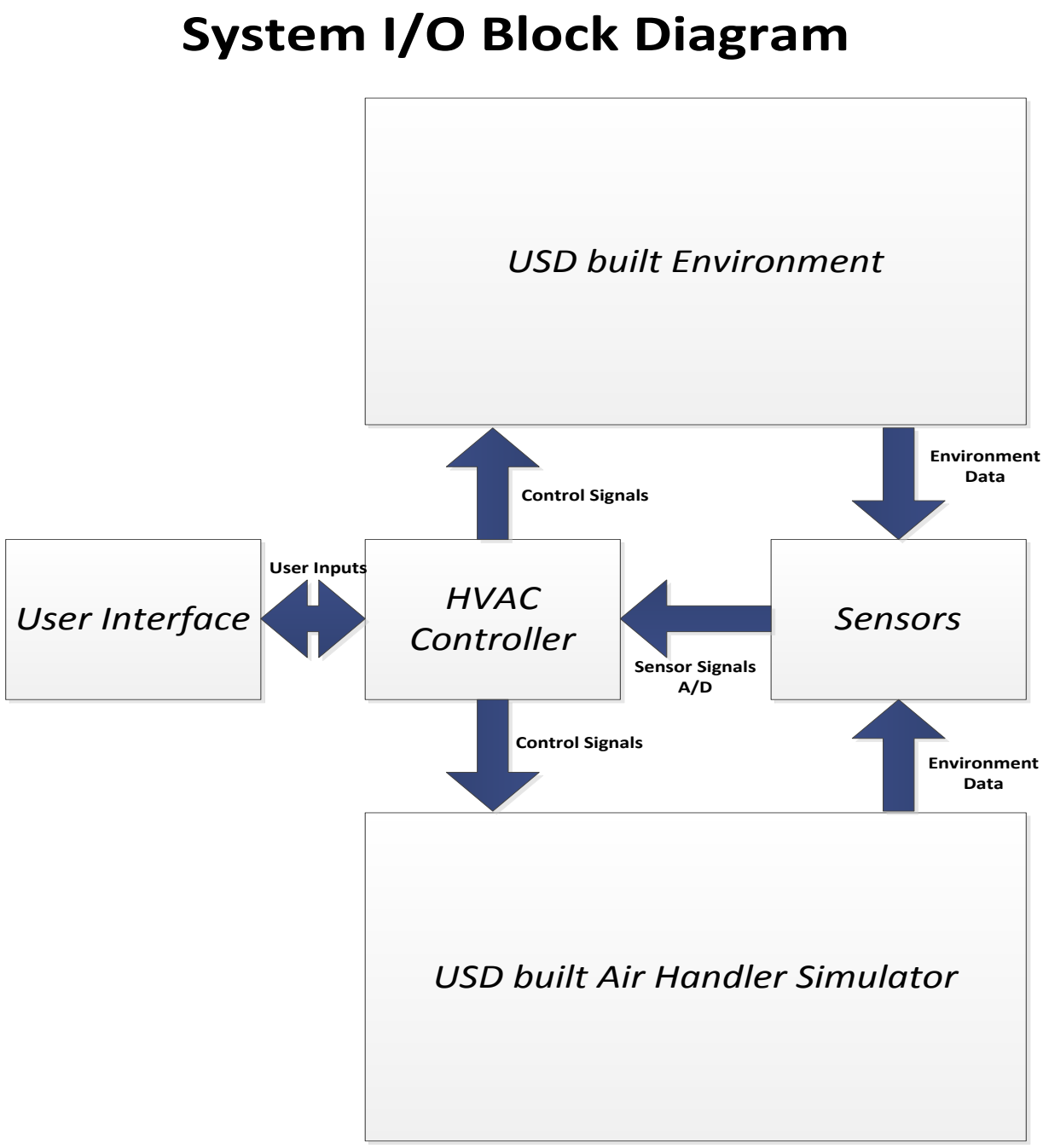

Figure 1 System I/O Block Diagram

3.1.1. Description

The overall vision of our design is to create a simulation of the generic HVAC system of a building. In particular we are referring to the air handler part of the system. The air handler is represented with an "H" model seen in the below schematic. This model is capable of demonstrating control over the air flow through a system using point sensors to collect data, dampers to control air flow, and a heating/cooling system to modify the air temperature. We have the capability of controlling most aspects of the system intelligently with this set up, which will be based on Siemens technology and Basic based programming that control the system consumed after recognizing the readings form the sensors.

3.1.2. Design Schematics

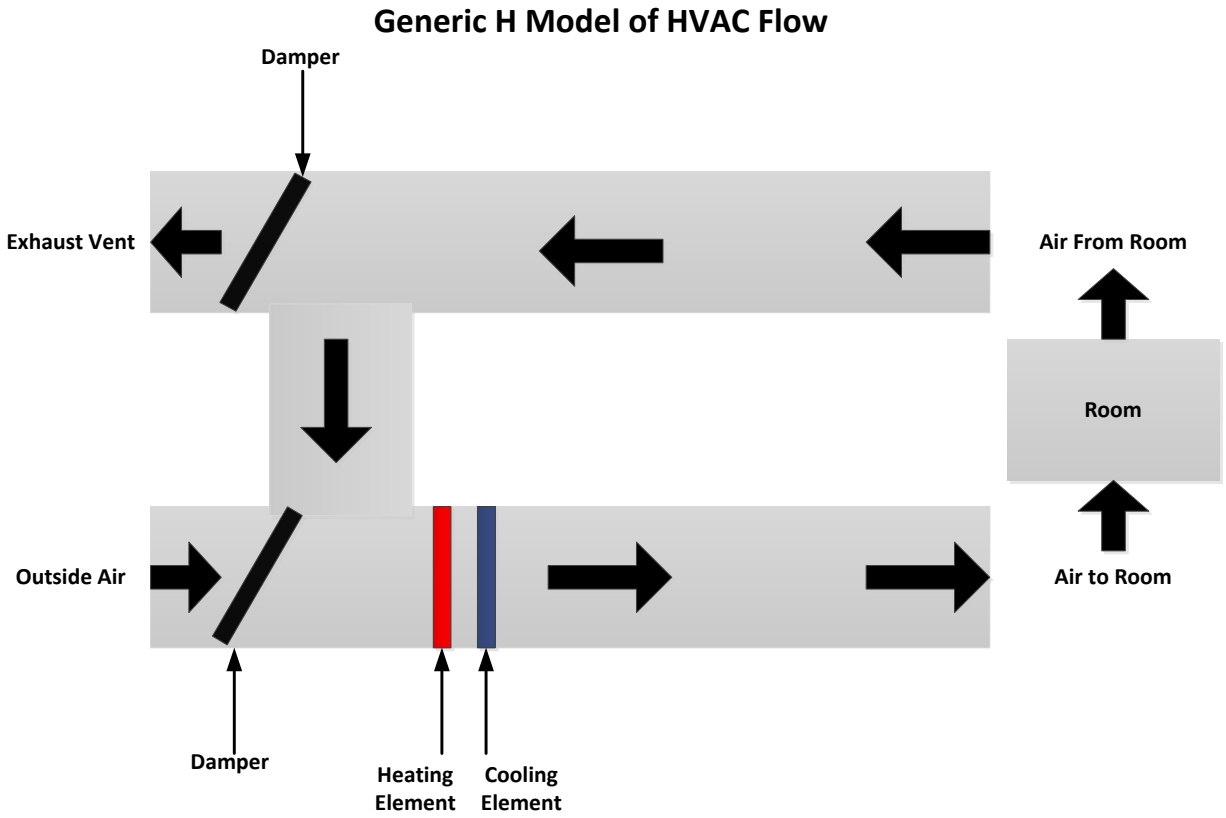

Figure 2 HVAC Model for an Air Handler

Environment Model

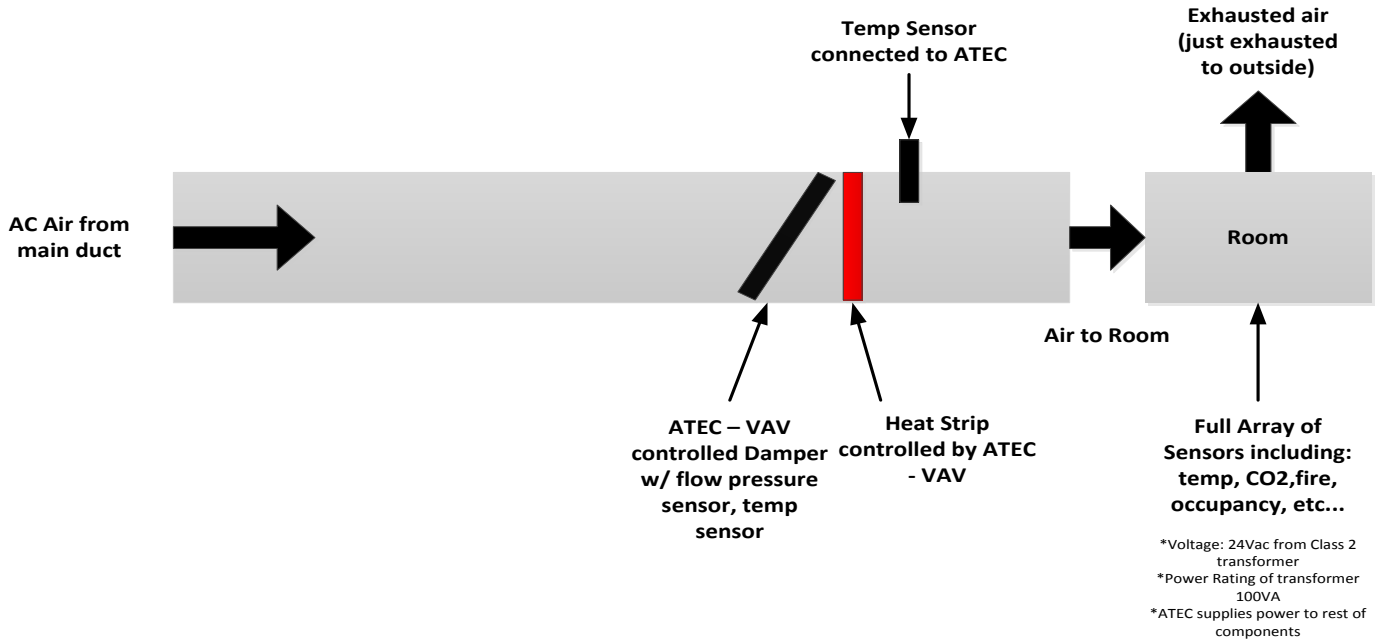
Temp Sensor connected to ATEC
Exhausted air (just exhausted to outside)
AC Air from main duct
Room
Air to Room
ATEC – VAV controlled Damper w/ flow pressure sensor, temp sensor
Heat Strip controlled by ATEC - VAV
Full Array of Sensors including: temp, CO2,fire, occupancy, etc...
*Voltage: 24Vac from Class 2 transformer
*Power Rating of transformer 100VA
*ATEC supplies power to rest of components

Figure 3 Environment Model

3.2. Functional Specifications

CR1: Build a virtual/physical HVAC system simulator

Functional specifications to meet CR1 include:

- Construction of physical HVAC simulator
- Integrating various pieces of simulator to make one connection with outside world

CR2: Integrate the simulator with Siemens building control equipment and environment

Functional specifications to meet CR2 include:

- Connect the simulator with the Siemens Building Control System
- Test the Simulator with sample code

CR3: Design a Basic based program to simulate integrated building functions

Functional specifications to meet CR3 include:

- Determine a sample control system to function inside of the simulator
- Program the code to run our building controls

CR4: Demonstrate the program, simulator, and Siemens equipment functions seamlessly

Functional specifications to meet CR4 include:

- Run the program on the simulated environment to demonstrate capabilities

3.3. Physical Specifications

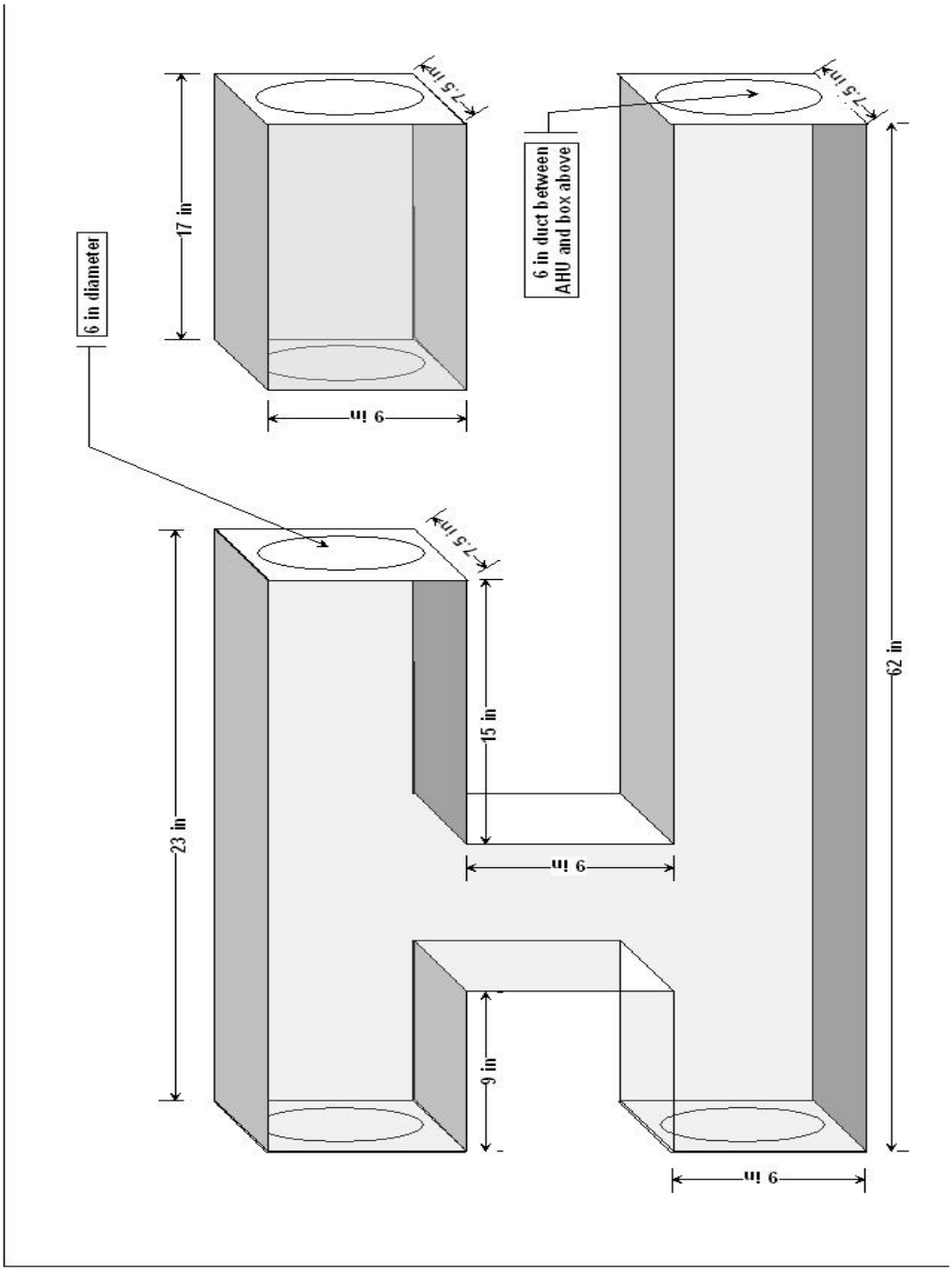

Figure 4 HVAC Model with Specifications

4. Design Analysis

4.1. System Analysis

This project consists of two main subsystems. One is the air handler (represented by the H model) and the other one is the actual room. The air handler model will be a scaled down version of an actual air handler in a building. Normally, the air handler is not a visible system to the occupant of a building. Our system will have a transparent model that will simulate the inner workings of an air handler. The air handler in a building is the main supplier of air to the building as a whole. The air handler is tasked with intake, heating, cooling, and exhausting the air for an entire building. It is controlled by the building set points to ensure a comfortable environment. When a particular zone in a building needs to be modified (i.e. an individual's office) a local controller such as an ATEC will control the air flow into the room. In some cases this can mean reheating the air or even cooling it back down depending on the zone user controlled set points. This led us to the development of our two models. We came up with the air handler "H" model to represent an actual handler, and it will be used to mimic the operations of the air handler. We will not be actually handling air with this model. The second model is a fully functional, full sized zone controlled by a lower level controller. This will be implemented with a Siemens ATEC controlling the air flow into an actual room. The ATEC will also have reheat capabilities. We wanted to have both models because of the customer asking us to have the ability to simulate an entire system. Without both we would not be simulating the global and local control capabilities of a HVAC system.

Since most aspects such as power have already been calculated we only need to follow the wiring guidelines in appendix 8.7 in order to have a properly powered system. In conjunction with this we need to be sure the components which are listed in the component data sheets are properly powered.

The air handler "H" model size was scaled down to match the duct size of our ATEC box a diameter of 6 inches. Going off the dimensions of a pre-existing H model that Siemens had we did a direct proportional scaling. This is generally known as similitude which is about how direct scaling would work in a scaled down system. This is shown in figure 4.

Since we are doing a system design rather than a component design our analysis will be on how the system responds to given environments. From various scenarios we will be able to acquire data and form trend lines on the systems power consumption and other elements such as the average temperature deviation from the set point. From these trend lines we can develop an even smarter system with a faster response time and doing so with less power consumed.

The reasoning behind the air handler not actually conditioning the air is mainly for economic and environment limitations. The room where the design is being implemented does not have the space to have a fully functioning heating and cooling system. Further, the room was not capable of supporting the heating and cooling system without piping water into the room. The economic reasons for the design were similar to the room limitations as it would have been expensive to pipe over chilled and heated water in order to have a proper heating and cooling system.

4.2. Subsystem Analysis and Design

The subsystems of our project are the Siemens control system and the HVAC simulator that we designed.

- Air Handler “H” Model: This subsystem will model the air handler functions while not actually modifying air. This system will compose of fans, dampers with actuators, temperature point sensors, and air quality sensors. It will mimic the physical aspect of handling the air by opening and closing intake and exhaust vents. It will also indicate if the system is in a heating or cooling routine. This

system will be controlled through our programming routines. A model of this can be seen in figure 2.

- Siemens System: The Siemens components constitute the nervous system of an HVAC system. The PXC module acts as the brain as it is the highest order controller in the system. The TX-I/O module acts as the spine to our system as all the inputs and outputs must travel through this module before it gets to the PXC. The sensors act as the nerve endings and tell the system about its surroundings. Used correctly these components can create a powerful system with limitless capabilities. Also part of this system is the lower order controller modules such as the ATEC and TEC modules that can act as like the PXC module but with limited capabilities. They can also be controlled by the PXC via a RS-485 cable. Controlling all of this is the APOGEE software. This is where the user can do all the programming and GUI design.

    - Computer Controls
    - Processor
    - ADC/DAC

- Environment: This is the actual room. The different devices in it will have to work in a way in which they satisfy the user's desire. We will need all three levels (management, automation and field level) working together for this to happen. Its main parts will be:
    - ATEC
    - Electric reheat
    - Temp Sensors
    - Damper

A model of this can be seen in figure 3. A wiring diagram can be found in appendix 8.2.2

- Program to run systems: This is our decision-maker. As it receives information from what the situation is in the room, it will compare it to the user's desires, which will also be read, and will act as needed in order to satisfy them. Flow diagrams of the main routine and subroutines can be found in appendix section 8.4.

5. Testing

Note: for a table of our test results, see appendix 8.10.

5.1 Verification & Validation Strategies

The following Validation Strategies would be implemented for the testing of Environment Lab product.

1. Unit Testing
2. Integration Testing
3. System Testing
4. Regression Testing
5. Performance Testing
6. User Acceptance Testing

5.1.1 System Testing

Test Cases are based on the design document for all the requirements mentioned in the test conditions.

Test Conditions:

1. All equipment being used are to be tested prior to the test case run in order to ensure the fidelity of the test results.
2. The lab environment initial conditions for the particular test case being run are set prior to running the test.
3. Ensure that the system program is loaded onto all appropriate controllers properly.

Measurements will be taken using one of the two approved methods. The first method is using LabVIEW to gather desired data points. The second method is to use the built in data tracker within the Insight software.

The desired data points that will be gathered will be power consumption and system response time. Another aspect that will be noted but not measured is the comfort of the room's atmosphere this will be purely subjective though.

5.1.2 Integration Testing

During Integration Testing, the system will be tested so that multiple components will be utilized to achieve a basic function with the goal to ensure that the system is working properly as a whole. No scenarios will be used in this testing.

Test Conditions

1. System is made to do simple tasks to validate operational status.
2. Non scenario based.
3. If a test is failed at any point the test will end with a fail.

Steps:

1. Power on the system via the two main power switches.
2. Load the desired program onto the PXC controller to run the system test
3. Allow the program to run automatically unless the test desired manual input such as a manual wall switch.
4. After 10 minutes the test is completed if no fails have occurred and the test is considered a pass.

5.1.3 Unit Testing

During Integration Testing, individual components of the Siemens' system will be tested to ensure that they are in proper working order.

Test Conditions

1. Install Siemens' HVAC components according to cut-sheets and manuals.

Steps:

1. Test all components to ensure they are powered on properly.
2. Test all measuring devices for accuracy (not feasible as we do not have calibrated tools to test accuracy).
3. Test all status indicators to ensure components are talking to each other.

5.2 Test Environment and Resource Requirements

The Requirements and Resources required for carrying out the Verification and Validation activities are given below.

Phase	Resources	Requirements
Unit Testing.	none	AC power
Integration Testing.	Insight Software	Appropriate RS-232 connection from computer terminal to PXC

5.3 Effort and Schedules.

The below table describes the effort and the schedules for the testing activities.

Activity	Start Date	End Date	Duration
Unit Testing (Test each individual unit)	4-17-2012	4-24-2012	7 days
Integration Testing	4-17-2012	4-30-2012	13 days
System Testing (Test Cases)	4-30-2012	5-5-2012	6 days

Note: The Schedule is tentative and subject to change.

5.4 Test Approach

The primary objective of Testing is to discover errors in the module or system at various levels and stages.

Test cases thus generated will be executed and deviation in functionality will be reported as errors for correction.

5.5 Defect Tracking & Reporting

Bugs and suggestions identified during any phase of testing would be reported immediately. The basis of identification of bugs and the classification of bugs is mentioned in the table below:

Category	**Description**
Severe	Functionality not working.
Major	Serious effect to the functionality.
Minor	Minor deviation in the functionality.
Cosmetic	Errors with respect to User Interface.
Suggestion	Suggestion for improvement.

The errors identified will be recorded and visited in a timely matter.

5.5.1 Defect Tracking Tool

All defects will be recorded in an Excel spreadsheet with color identifications noting their severity and current status.

5.5.2 Defect Resolution Procedure

Defects logged on to the defect tracking tool should be resolved at the earliest time possible. Known defects will be given a status color based on their current resolution status. There are three stages of resolution status reported, resolution in progress, and defect resolved.

5.5.3 Priority Level

The priority level for the errors reported will be rated as given below:

Level	**Description**
Must Fix	Fix the bug at the Immediately.
Should Fix	Important, Fix at the earliest.
Fix when have time	Fix the bug when time permits.
Low Priority	Not exactly a bug.

5.5.4 Status of Bugs

The status of bugs will have four options. They are briefed below:

Status	**Description**
Open	The error reported is open.
Resolved	The error is resolved.
Close	The error is re-tested and closed.
Re-Open	The error is re-opened.

When the test engineer opens a bug, the developer resolves the bug and changes the status of the error to “Resolved”. The test engineer re-tests the error and Closes. If the error is repeated while in any phase of testing, the error would be re-opened.

6. Project Plan

"Inventing is a combination of brains and materials. The more brains you use, the less material you need." Charles Kettering, automotive inventor

6.1 Fabrication

The fabrication part of this project is fairly straightforward. Building the simulator will require very simple woodworking. The various parts of the simulator can be connected with a straight forward wiring system.

6.2. Project Deliverables

The primary deliverable for this project is the HVAC system simulator. By the end of the first semester of our senior project we will have a solid plan of how we will build the simulator and integrate the Siemens Control System. In the second semester, we will build the system and integrate the simulator with the Siemens Control System. We will additionally have the code designed by the second semester to test on our simulator.

First Semester

- Preliminary Design Report
- Full set of engineering drawings for mechanical aspects of the project
- Bill of Materials
- Cost estimates

- **Programming Medium.** The design medium for the programming is the APOGEE Insight software provided by Siemens. The language is a hybrid of Basic and Fortran.
- **Software.** The software component of our project must be flowcharted.
- **Sensors.** We must have the various sensors and HVAC controls in hand and must have experimentally characterized them.
- **Motors and Drivers.** The motors and controlled drivers must be in hand and experimentally characterized and demonstrated each particular motor, driver, etc. working.

- **Circuit Design.** The basic topology of any significant electronic or power circuitry must be selected and you must demonstrate some performance.
- **Inventory.** Take an inventory of our current supplies and determine what we will need to build our design.

Second Semester

- Final Design Report including test results
- Physical simulator
    - Includes all hardware pieces integrated into system
- Integration of simulator and Siemens control systems
    - All pieces wired together
- A working prototype that meets customer requirements
    - Verify the prototype works with sample program
- Analysis of any failed components

6.3. Schedule

We have decided upon the following timeline to meet our design goals. The project milestones for the first semester are centered on the planning process, while the milestones for the second semester are centered on the assembly of the simulator. See the full Gantt Chart in Appendix Section 8.7. Currently, we have two working demonstrations utilizing a temperature sensor and the fire alarm system. So far we have meet all milestones according to Gantt Chart for the first semester.

6.4. Budget

There were many considerations that went into the planning of the budget. First of these considerations is that our max budget is $1,500. The reasoning behind this is that we have already procured most of our parts from Siemens. Our budget then goes to the building of the simulator. This includes building materials such as wood, ducting, and mechanical devices such as condensers. Most of the budget will be toward the construction of the environment. However, some of the budget is allocated to the electronics that will control the environment or act as the user interface. This includes items such as a microcontroller.

6.5. Personnel

"Great discoveries and improvements invariably involve the cooperation of many minds."
Alexander Graham Bell

We decided to delegate responsibility of the various subsystems of our project to the various team members. While every member is responsible for every part of the project, each team member is responsible for taking charge of each subsystem in the following manner.

Martin de la Herran

- Simulator and various components
    - Taking an inventory of our parts in hand and determining what materials we need to obtain to do our project.
    - Understanding how the different components work together.
    - Determining what we need to learn about each component to run our simulator.
    - Detailing the physical and electronic integrations of the components for the simulator.
    - Power Budget

Robert Driggers

- Programming the Basic based code
    - Learning the Basic based coding process
    - Understanding the integration of the Basic based code and how to program using the Siemens system.
- Generate higher level block diagrams describing functionality of system

Marlowe Quart

- Siemens system
    - Understanding the Siemens system and how to integrate the simulator, as well as run different programs.
    - Determine if we have all of the components of the Siemens system in hand
    - Study the user manuals of the Siemens system to learn operation
- Documentation
    - Preparing the documentation and planning the work to be completed.

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6. Acknowledgments

When an engineering project works, the most important part of it has been accomplished. We are honored to say that our project ended up successfully working after months of hard work but reaching this goal would not have been possible without the following people:

- Boris Pavlakovic - Siemens
- Jon Wright – Siemens
- Dr. Fernando de Cuadra – ICAI
- Dr. Kim – USD
- Prof. Wickwire – USD
- Facilities Team – USD
- Siemens – Sponsor

Thank you very much.

7. Appendices

7.1. Resume

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EDUCATION

UNIVERSITY OF SAN DIEGO San Diego, CA
B. S. / B. A., Major in Electrical Engineering & Minor in Mathematics May 2012

- *Leadership*: Team Leader of Senior Design Project (Integration of Siemens HVAC System)
  Recently received invitation to become an official representative of the university
  Collaborated in orientation for students going abroad (speech to approx. 100 students)
- *Membership*: Part of two intramurals soccer teams (Champions of Fall 2011 and Finalists Spring 2012)
  Member of *Leaders of Tomorrow* organization

ICAI - UNIVERSIDAD PONTIFICIA DE COMILLAS Madrid, Spain
B. S. / B. A., Major in Industrial Engineering (Equivalent to Master's Degree in the U.S.) June 2012

- *Leadership*: Class Representative - Elected all times when candidate (Freshman & Junior years)
  In charge of incoming American exchange students
- *Membership*: College Board Member – Privilege to vote for University Principal

IESE BUSINESS SCHOOL Madrid, Spain
General Business Skills Program Oct 2009 – May 2010

- 1st place in Business Case Contest – M&A Case

EXPERIENCE

VERIGY / TOUCHDOWN TECHNOLOGIES Los Angeles, CA
Intern, Engineering Design May 2011 – Aug 2011

- Developed probe card architecture in search of financial benefits for following 5 years and presented finalized objectives to all board members
- Created user-friendly program for company use and was implemented that summer

BUREAU INTERNATIONAL DES EXPOSITIONS Paris, France
Intern, Financial Analyst June 2010 – July 2010

- Controlled financial aspects for the EXPO 2015 in Milan by analyzing differences between promises as candidates and real budget after economic crisis - Received letter of recommendation from CEO

MSL Belgrade, Serbia
Electronic Systems Assistant June 2009 – July 2009

- Member of team that was in charge of all electronic systems at the European College Games (Controlled input and output of live results for Athletics)

AON Hamburg, Germany
Rotational Intern June 2008 – July 2008

- Studied and analyzed activity at departments of Retail (Industrial Property and Aviation) and Reinsurance (Public Relations, Global Clients, Retrocession and Earthquake scenarios)

DEUTSCHE BANK Munich, Germany
Intern, Financial Analyst June 2007 – July 2007

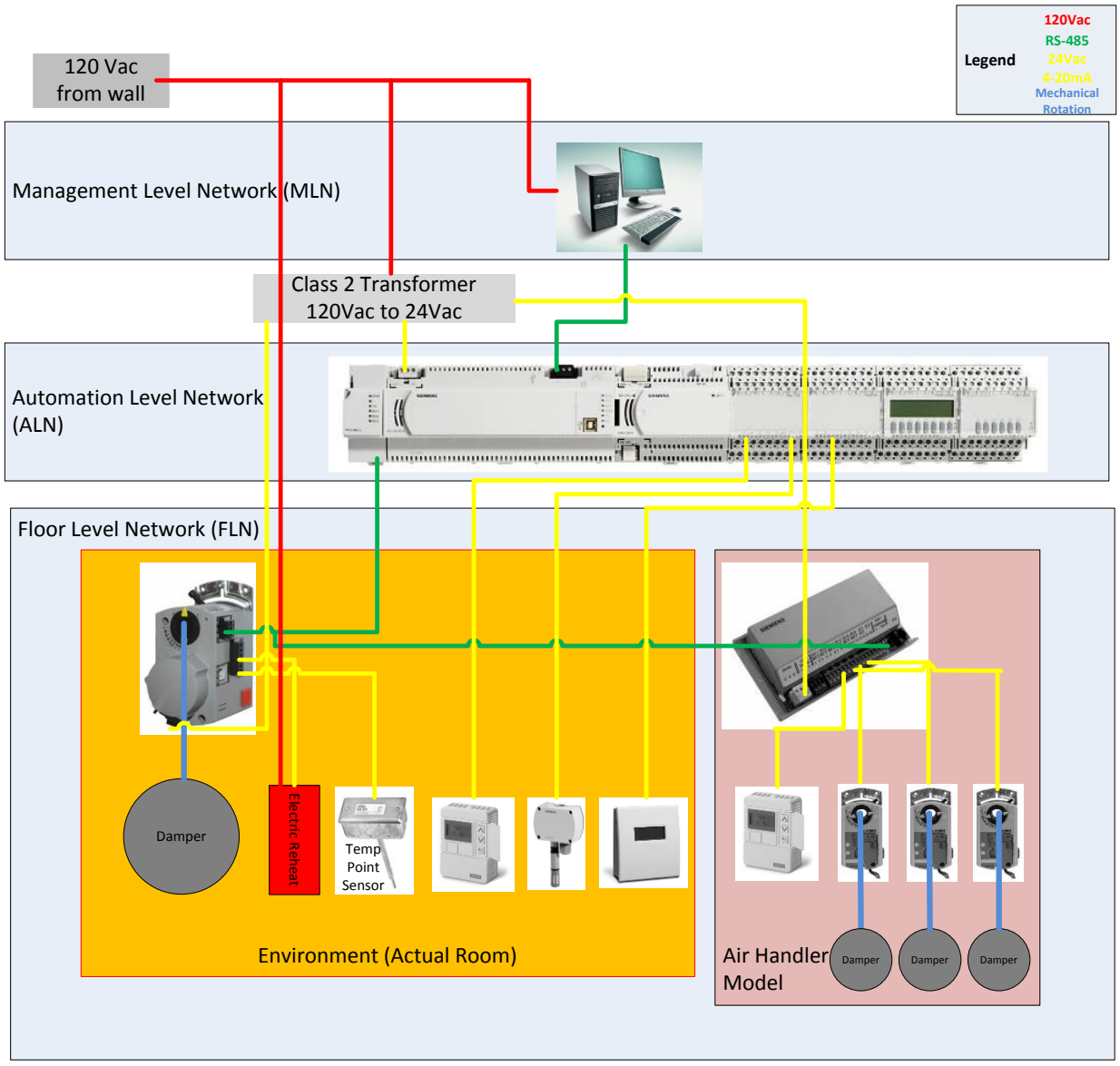
- Dealt with Swap Options, Put Options, Call Options
- Analysis of major energy and utilities company (>$20Bn sales) regarding DB's investment in it

ADDITIONAL

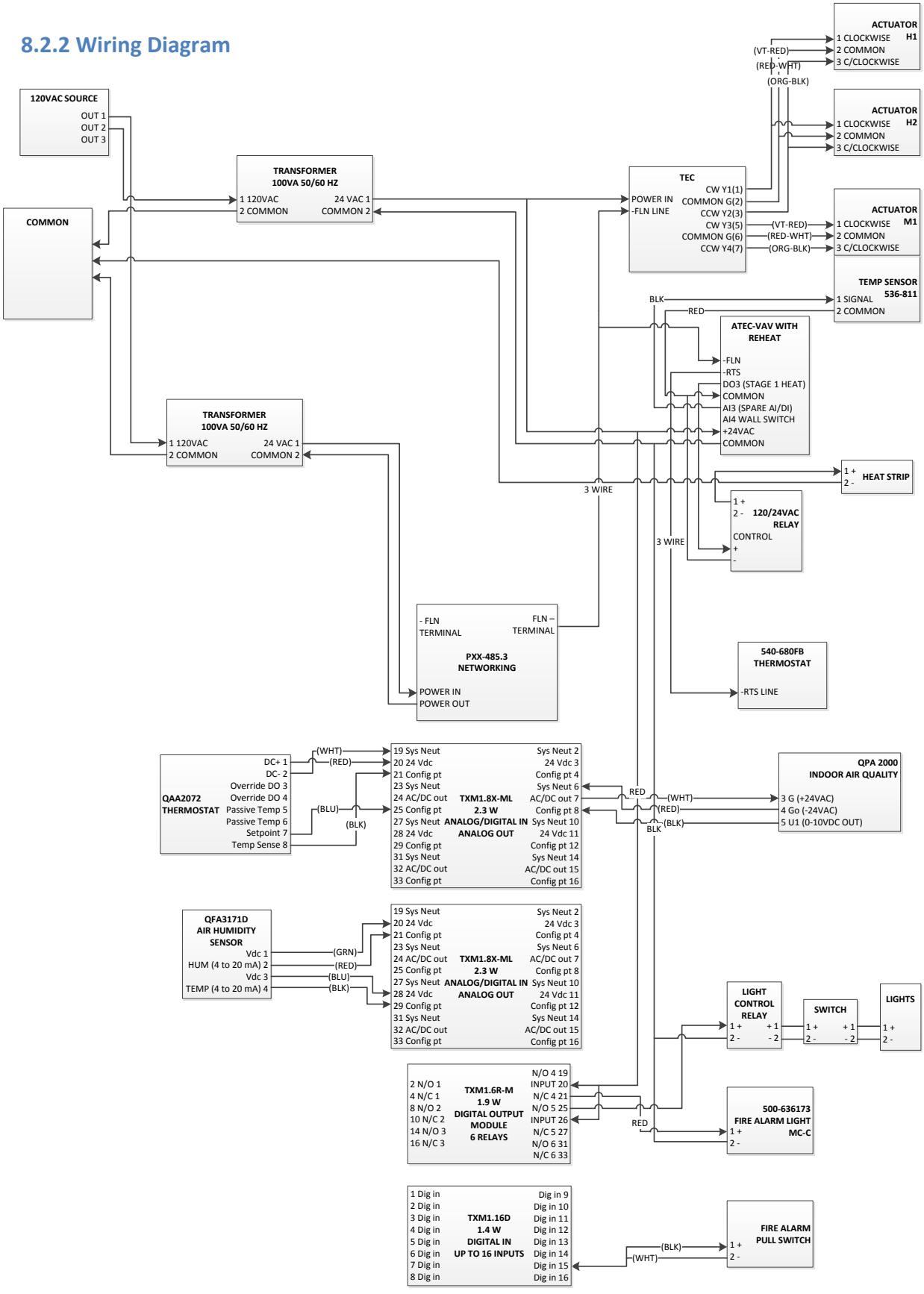
- *Dual Citizenship*: U.S.A. and Spain
- *Languages*: English (Native), Spanish (Native), French (Fluent) and German (Basic)
- *Website Administrator*: Creation, design, development and maintenance of two websites
- *Programming*: C and C++ (advanced), Microsoft Office (advanced)
- *Sports*: Ski (Instructor at Sherpa Club), Tennis (Instructor), Soccer (High School Team), Surf and Golf
- *Counselor*: Responsible for 10 year-olds at Robin Hood Summer Camp, NH (Summer 2006)

8.2. System Diagrams

8.2.1 System Overview



8.2.2 Wiring Diagram



8.3. Budget

Below is the detailed budget. Most of the budget is dedicated to the mechanical devices that are involved in the heating and cooling of the air in our environment. The next major expenditure deals with the construction of the environment. The environment is the air passages which the air will flow through. The next expenditure is the electronics that will act as controlling devices or as an user interface.

Original forecast budget:

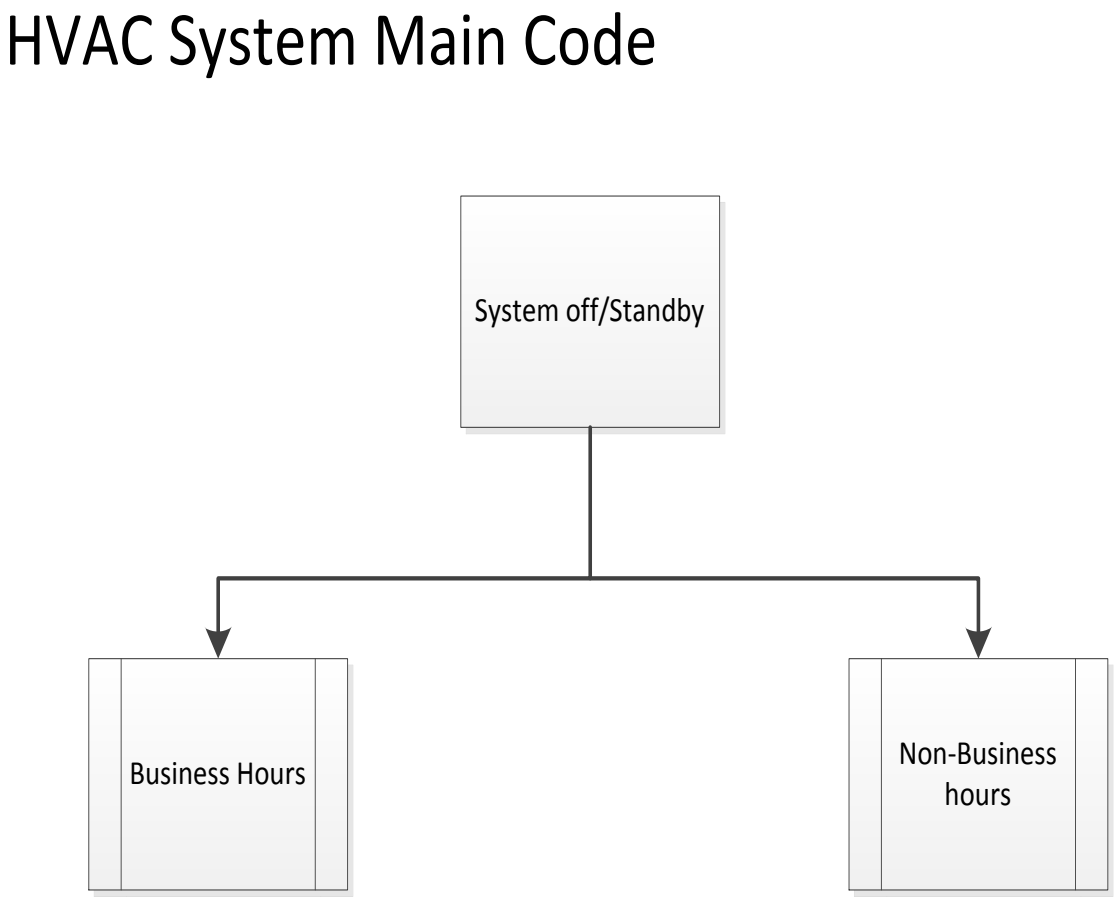
Budget							
Parts/Materials	UPC/ Manufactor Number	Description/Name	Supplier	Quantity	Cost	Tax	Cost+Tax
Ducting	202907357	4in x 25ft duct pipe	Home Depot	1	$ 24.99	$ 1.94	$ 26.93
Microprocessor	PIC18F2580-I/ML	microprocessor - Microchip	Jameco Electronics	1	$ 11.29	$ 0.87	$ 12.16
Circuit Components		Assorted Components (Grab Bag)	Jameco Electronics	1	$ 19.95	$ 1.55	$ 21.50
Wood (for Frame)	-	plywood sheets	Home Depot	2	$ 21.47	$ 3.33	$ 49.60
Plexigass	202038053	plexiglass Sheet	Home Depot	2	$ 109.00	$ 16.90	$ 251.79
Compressor	Senco PC1010 Compressor 1/2 HP 1 gal	air compressor	Amazon.com	1	$ 125.99	$ 9.76	$ 135.75
Condensor	Haier HNSE032 3.2 Compact Refrigerator	take one out of a small fridge	Home Depot	1	$ 149.99	$ 11.62	$ 161.61
DC Power Supply	841163036884	Thermaltake PS	Frys	1	$ 99.99	$ 7.75	$ 107.74
Nails/Screws	-	Box of wood scews	Home Depot	1	$ 29.98	$ 2.32	$ 32.30
Fan	AD0212MB-K50(S)	FAN, 12VDC, 2.40CFM, 25x25x6, 90mA, BALL/SLEEVE, 5.50" LEADS, UL/CUL/TUV	Jameco Electronics	2	$ 11.95	$ 1.85	$ 27.60
Wires	14759011637	100ft Spool of Wire	Frys	1	$ 9.99	$ 0.77	$ 10.76
LEDS	-	LEDS of various colors	Jameco Electronics	50	$ 0.15	$ 0.58	$ 36.56
						Grand Total:	$ 874.32

Revised budget:

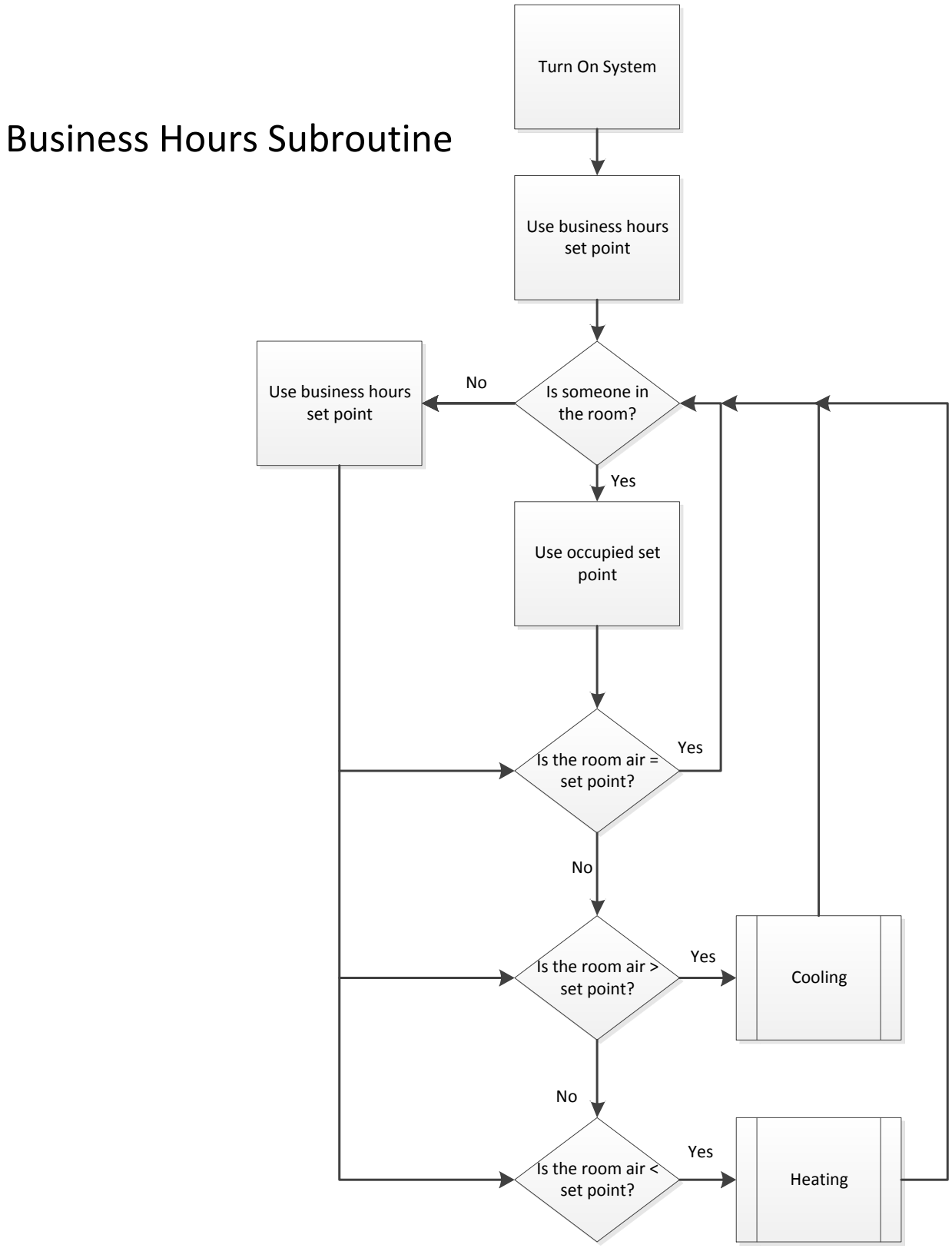
Budget							
Parts/Materials	UPC/ Manufactor Number	Description/Name	Supplier	Quantity	Cost	Tax	Cost+Tax
Ducting	202907357	6in x 25ft duct pipe	USD Facilities	1	$ -	$ -	$ -
Wood (for Frame)	-	particleboard	Home Depot	2	$ 19.98	$ 3.10	$ 46.15
		toggle bolt	Home Depot	2	$ 3.90	$ 0.60	$ 9.01
		2 x 4 studs	Home Depot	3	$ 2.34	$ 0.54	$ 8.65
		lumber cutting	Home Depot	1	$ 4.00	$ 0.31	$ 4.31
Plexigass	202038053	plexiglass Sheet	Home Depot	1	$ 150.00	$ 11.63	$ 161.63
Paint		tray set	Home Depot	1	$ 9.97	$ 0.77	$ 10.74
		paintbrush rollers 3x	Home Depot	1	$ 4.97	$ 0.39	$ 5.36
		white satin	Home Depot	2	$ 14.22	$ 2.20	$ 32.85
Nails/Screws	-	1/2 in, 1 lb screws	Home Depot	1	$ 4.91	$ 0.38	$ 5.29
		3in, 5/8 radius hinge	Home Depot	2	$ 2.58	$ 0.40	$ 5.96
		angle framing anchor	Home Depot	14	$ 0.88	$ 0.95	$ 25.69
		wood screws 12x2	Home Depot	1	$ 7.56	$ 0.59	$ 8.15
Wires	14759011637	various wires received	Siemens	1	$ -	$ -	$ -
						Grand Total:	$ 323.78

8.4. Flowcharts for Software

8.4.1 Main Routine

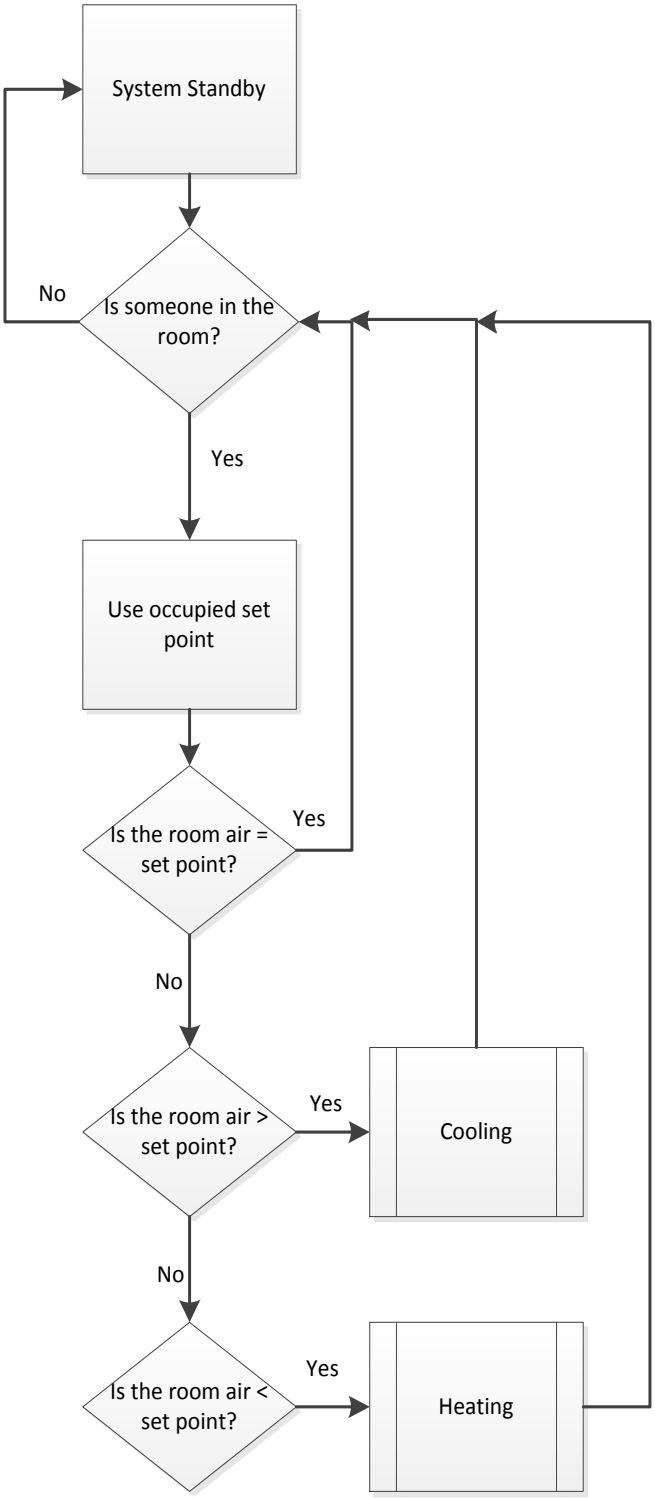


8.4.2 Business Hours

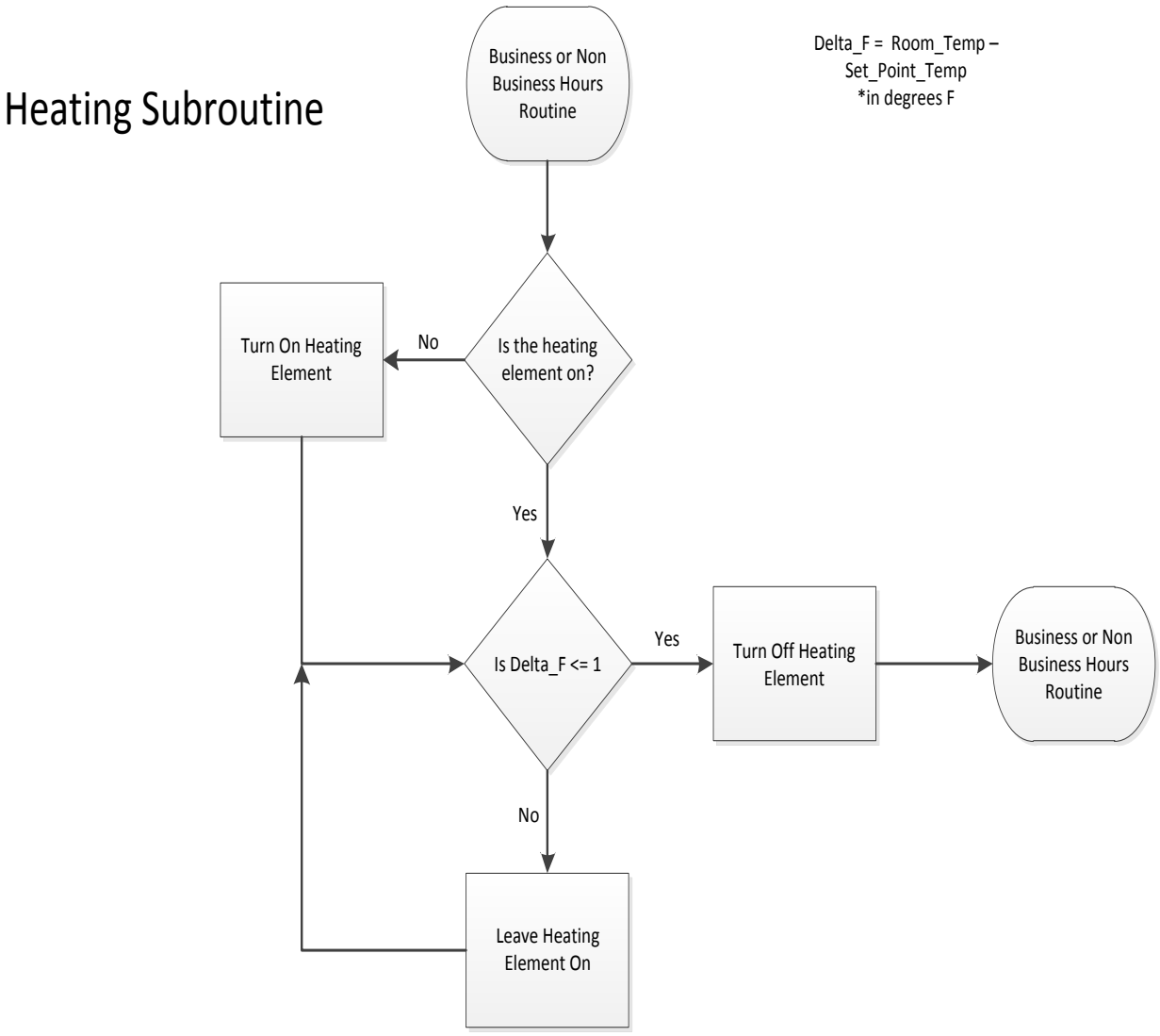


8.4.3 Non-Business Hours

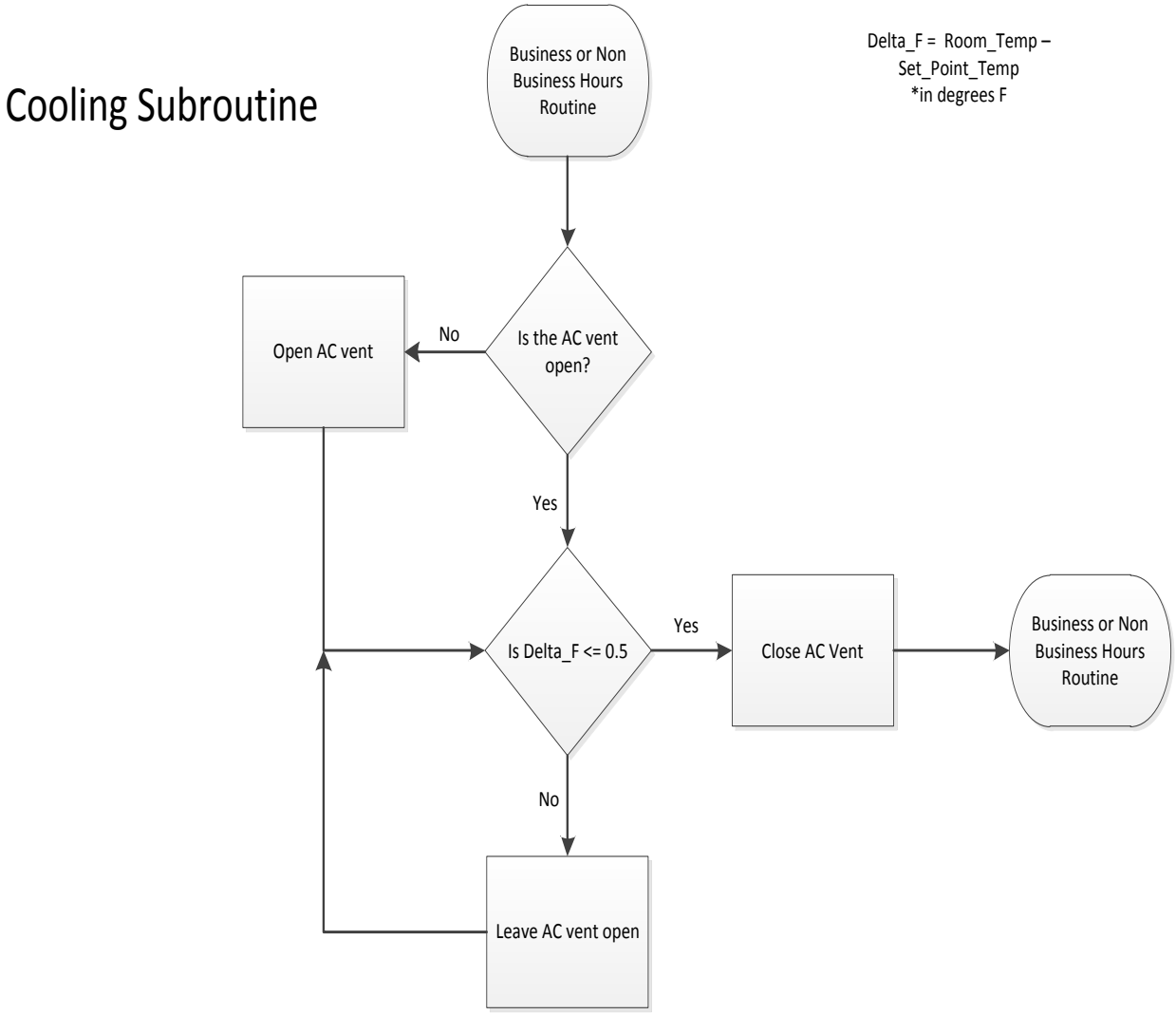
Non-Business Hours Subroutine



8.4.4 Heating


Heating Subroutine
Business or Non Business Hours Routine
Delta_F = Room_Temp – Set_Point_Temp
*in degrees F
Is the heating element on?
No
Turn On Heating Element
Yes
Is Delta_F <= 1
Yes
Turn Off Heating Element
Business or Non Business Hours Routine
No
Leave Heating Element On

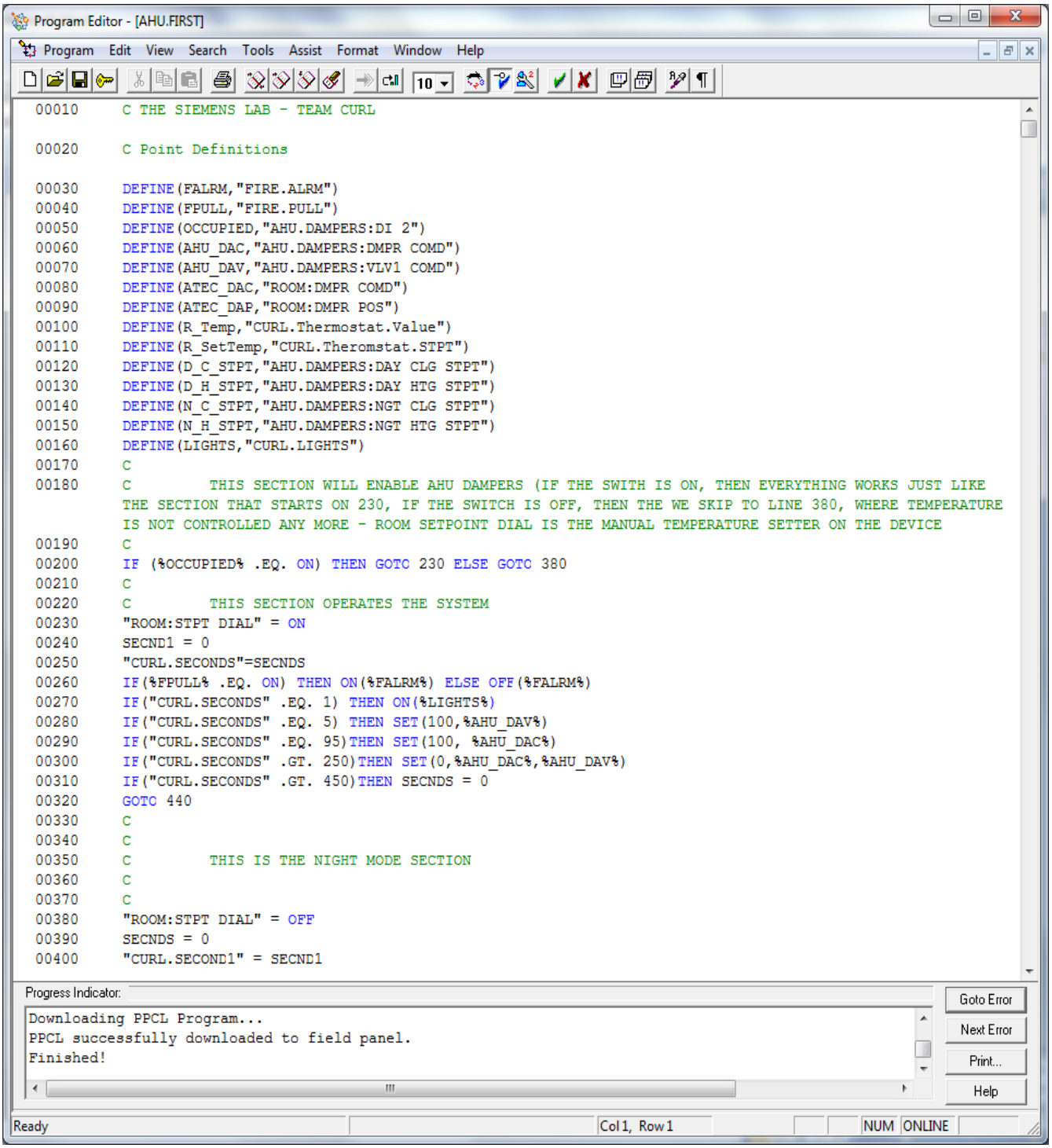
8.4.5 Cooling

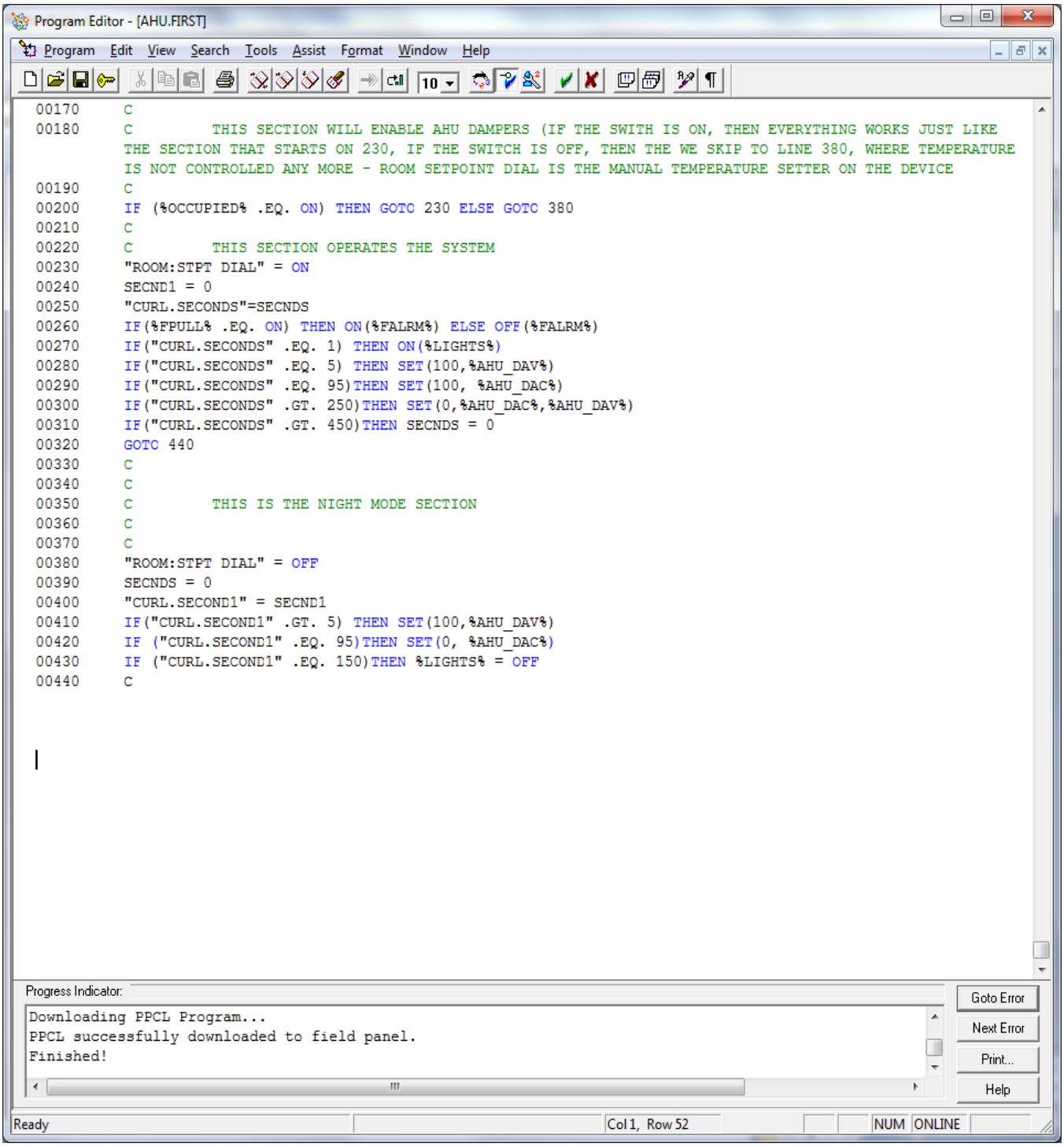

Cooling Subroutine
Business or Non Business Hours Routine
Delta_F = Room_Temp – Set_Point_Temp
*in degrees F
Is the AC vent open?
No
Open AC vent
Yes
Is Delta_F <= 0.5
Yes
Close AC Vent
Business or Non Business Hours Routine
No
Leave AC vent open

8.5. Programming

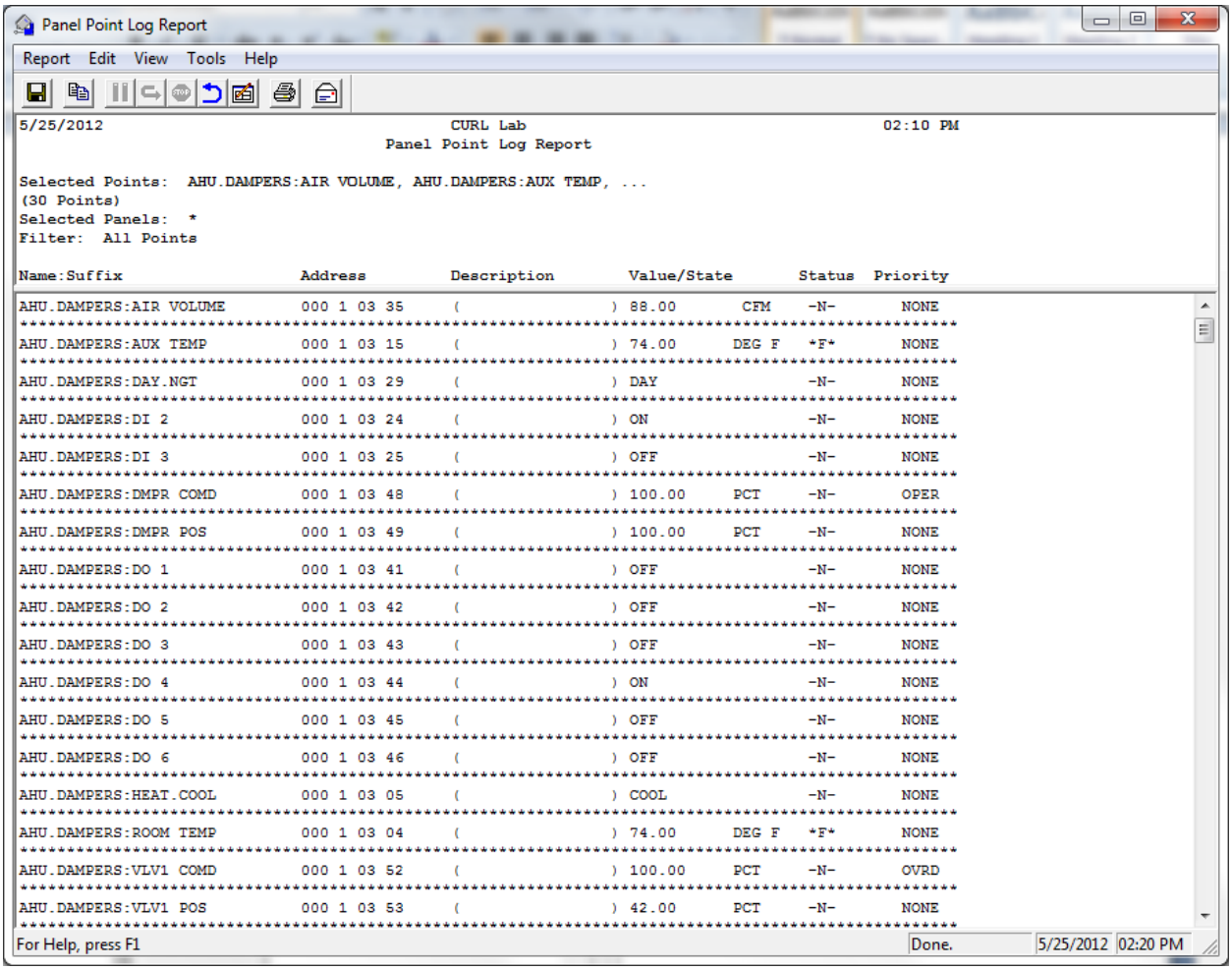
We programmed the system to work in a very user friendly way, which means that we saw one version of the system, and the user saw a very simplified one, with graphics and easy-to-use buttons and easy-to-understand outputs.

We did our code using the Siemens language. We did many tests and tried different things to suit different needs. This is an example of one of our codes, where we set it to have two possible cycles:


Program Editor - [AHU.FIRST]
Program Edit View Search Tools Assist Format Window Help
00010 C THE SIEMENS LAB - TEAM CURL
00020 C Point Definitions
00030 DEFINE(FALRM,"FIRE.ALRM")
00040 DEFINE(FPULL,"FIRE.PULL")
00050 DEFINE(OCCUPIED,"AHU.DAMPERS:DI 2")
00060 DEFINE(AHU_DAC,"AHU.DAMPERS:DMPR COMD")
00070 DEFINE(AHU_DAV,"AHU.DAMPERS:VLV1 COMD")
00080 DEFINE(ATEC_DAC,"ROOM:DMPR COMD")
00090 DEFINE(ATEC_DAP,"ROOM:DMPR POS")
00100 DEFINE(R_Temp,"CURL.Thermostat.Value")
00110 DEFINE(R_SetTemp,"CURL.Theromstat.STPT")
00120 DEFINE(D_C_STPT,"AHU.DAMPERS:DAY CLG STPT")
00130 DEFINE(D_H_STPT,"AHU.DAMPERS:DAY HTG STPT")
00140 DEFINE(N_C_STPT,"AHU.DAMPERS:NGT CLG STPT")
00150 DEFINE(N_H_STPT,"AHU.DAMPERS:NGT HTG STPT")
00160 DEFINE(LIGHTS,"CURL.LIGHTS")
00170 C
00180 C THIS SECTION WILL ENABLE AHU DAMPERS (IF THE SWITH IS ON, THEN EVERYTHING WORKS JUST LIKE THE SECTION THAT STARTS ON 230, IF THE SWITCH IS OFF, THEN THE WE SKIP TO LINE 380, WHERE TEMPERATURE IS NOT CONTROLLED ANY MORE - ROOM SETPOINT DIAL IS THE MANUAL TEMPERATURE SETTER ON THE DEVICE
00190 C
00200 IF (%OCCUPIED% .EQ. ON) THEN GOTO 230 ELSE GOTO 380
00210 C
00220 C THIS SECTION OPERATES THE SYSTEM
00230 "ROOM:STPT DIAL" = ON
00240 SECND1 = 0
00250 "CURL.SECONDS"=SECNDS
00260 IF(%FPULL% .EQ. ON) THEN ON(%FALRM%) ELSE OFF(%FALRM%)
00270 IF("CURL.SECONDS" .EQ. 1) THEN ON(%LIGHTS%)
00280 IF("CURL.SECONDS" .EQ. 5) THEN SET(100,%AHU_DAV%)
00290 IF("CURL.SECONDS" .EQ. 95)THEN SET(100, %AHU_DAC%)
00300 IF("CURL.SECONDS" .GT. 250)THEN SET(0,%AHU_DAC%,%AHU_DAV%)
00310 IF("CURL.SECONDS" .GT. 450)THEN SECNDS = 0
00320 GOTO 440
00330 C
00340 C
00350 C THIS IS THE NIGHT MODE SECTION
00360 C
00370 C
00380 "ROOM:STPT DIAL" = OFF
00390 SECNDS = 0
00400 "CURL.SECOND1" = SECND1
Progress Indicator:
Downloading PPCL Program...
PPCL successfully downloaded to field panel.
Finished!
Goto Error
Next Error
Print...
Help
Ready
Col 1, Row 1
NUM ONLINE


Program Editor - [AHU.FIRST]
Program Edit View Search Tools Assist Format Window Help
00170 C
00180 C THIS SECTION WILL ENABLE AHU DAMPERS (IF THE SWITH IS ON, THEN EVERYTHING WORKS JUST LIKE THE SECTION THAT STARTS ON 230, IF THE SWITCH IS OFF, THEN THE WE SKIP TO LINE 380, WHERE TEMPERATURE IS NOT CONTROLLED ANY MORE - ROOM SETPOINT DIAL IS THE MANUAL TEMPERATURE SETTER ON THE DEVICE
00190 C
00200 IF (%OCCUPIED% .EQ. ON) THEN GOTO 230 ELSE GOTO 380
00210 C
00220 C THIS SECTION OPERATES THE SYSTEM
00230 "ROOM:STPT DIAL" = ON
00240 SECND1 = 0
00250 "CURL.SECONDS"=SECNDS
00260 IF(%FPULL% .EQ. ON) THEN ON(%FALRM%) ELSE OFF(%FALRM%)
00270 IF("CURL.SECONDS" .EQ. 1) THEN ON(%LIGHTS%)
00280 IF("CURL.SECONDS" .EQ. 5) THEN SET(100,%AHU_DAV%)
00290 IF("CURL.SECONDS" .EQ. 95)THEN SET(100, %AHU_DAC%)
00300 IF("CURL.SECONDS" .GT. 250)THEN SET(0,%AHU_DAC%,%AHU_DAV%)
00310 IF("CURL.SECONDS" .GT. 450)THEN SECNDS = 0
00320 GOTO 440
00330 C
00340 C
00350 C THIS IS THE NIGHT MODE SECTION
00360 C
00370 C
00380 "ROOM:STPT DIAL" = OFF
00390 SECNDS = 0
00400 "CURL.SECOND1" = SECND1
00410 IF("CURL.SECOND1" .GT. 5) THEN SET(100,%AHU_DAV%)
00420 IF ("CURL.SECOND1" .EQ. 95)THEN SET(0, %AHU_DAC%)
00430 IF ("CURL.SECOND1" .EQ. 150)THEN %LIGHTS% = OFF
00440 C
Progress Indicator:
Downloading PPCL Program...
PPCL successfully downloaded to field panel.
Finished!
Goto Error
Next Error
Print...
Help
Ready
Col 1, Row 52
NUM ONLINE

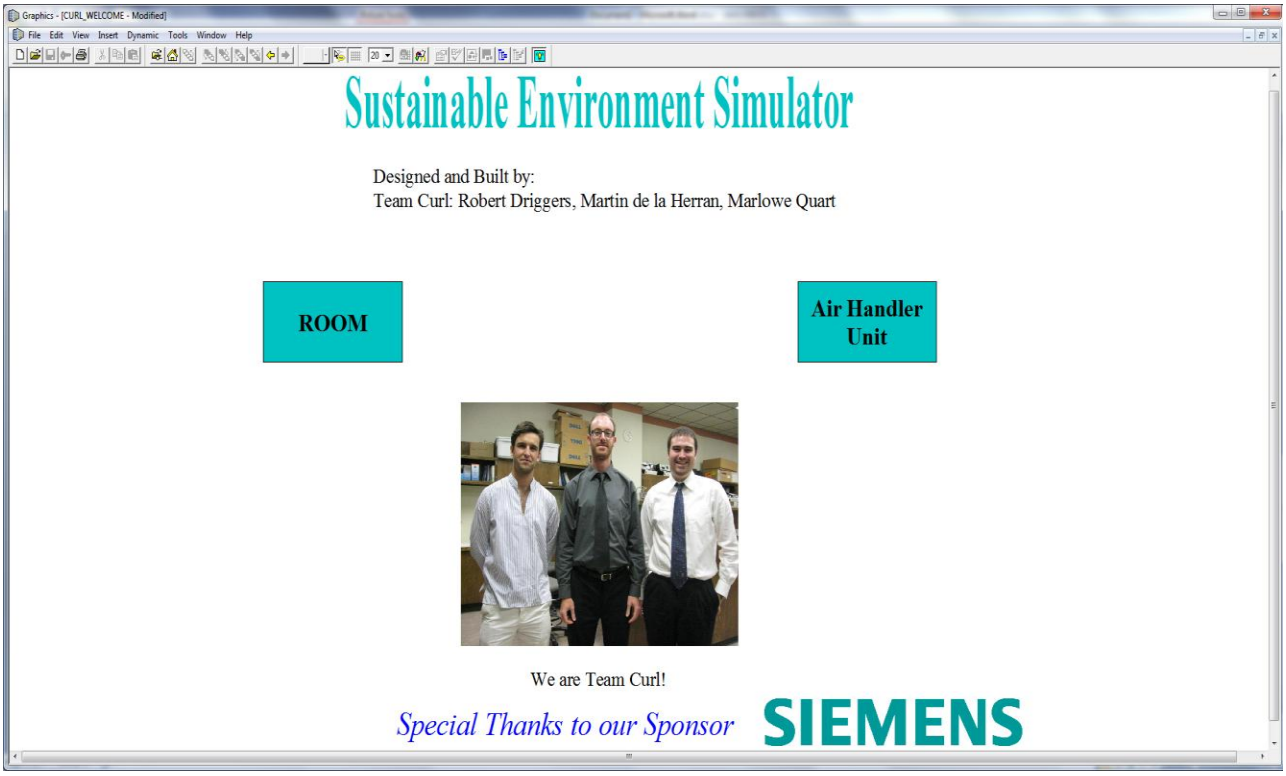
In order to program this we could manage more than one hundred points that were being controlled by our systems, including all the sensors, the ATEC, the PXC controller, the air handler,… Here is an example of the points that we could see to program this:


Panel Point Log Report
Report Edit View Tools Help
5/25/2012 CURL Lab 02:10 PM
Panel Point Log Report
Selected Points: AHU.DAMPERS:AIR VOLUME, AHU.DAMPERS:AUX TEMP, ...
(30 Points)
Selected Panels: *
Filter: All Points
Name:Suffix Address Description Value/State Status Priority
AHU.DAMPERS:AIR VOLUME 000 1 03 35 ( ) 88.00 CFM -N- NONE
AHU.DAMPERS:AUX TEMP 000 1 03 15 ( ) 74.00 DEG F *F* NONE
AHU.DAMPERS:DAY.NGT 000 1 03 29 ( ) DAY -N- NONE
AHU.DAMPERS:DI 2 000 1 03 24 ( ) ON -N- NONE
AHU.DAMPERS:DI 3 000 1 03 25 ( ) OFF -N- NONE
AHU.DAMPERS:DMPR COMD 000 1 03 48 ( ) 100.00 PCT -N- OPER
AHU.DAMPERS:DMPR POS 000 1 03 49 ( ) 100.00 PCT -N- NONE
AHU.DAMPERS:DO 1 000 1 03 41 ( ) OFF -N- NONE
AHU.DAMPERS:DO 2 000 1 03 42 ( ) OFF -N- NONE
AHU.DAMPERS:DO 3 000 1 03 43 ( ) OFF -N- NONE
AHU.DAMPERS:DO 4 000 1 03 44 ( ) ON -N- NONE
AHU.DAMPERS:DO 5 000 1 03 45 ( ) OFF -N- NONE
AHU.DAMPERS:DO 6 000 1 03 46 ( ) OFF -N- NONE
AHU.DAMPERS:HEAT.COOL 000 1 03 05 ( ) COOL -N- NONE
AHU.DAMPERS:ROOM TEMP 000 1 03 04 ( ) 74.00 DEG F *F* NONE
AHU.DAMPERS:VLV1 COMD 000 1 03 52 ( ) 100.00 PCT -N- OVRD
AHU.DAMPERS:VLV1 POS 000 1 03 53 ( ) 42.00 PCT -N- NONE
For Help, press F1
Done.
5/25/2012 02:20 PM

In this case some of the points related to the damper are shown. For example, the first one is the amountof air that is coming in, the second one is the temperature in the duct (we have another thermeter right by the damper), the third one is the mode (day mode), etc. We use all these points and many more (up to 200 points in total) to set conditions and goals when we write our program.

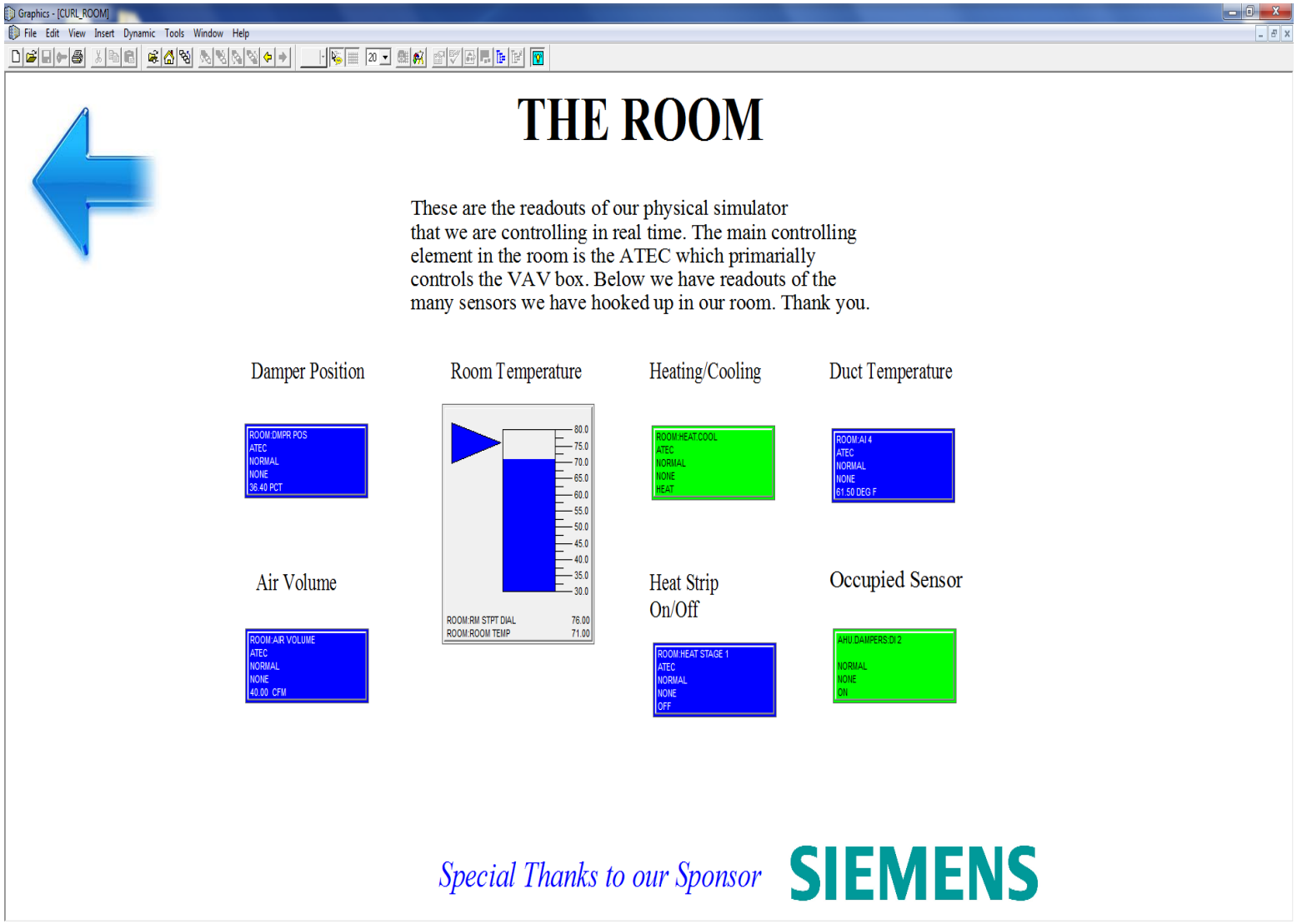
8.5.1. Graphics

We designed an easy way for a normal person to see what is going on in the room. Once any user starts the program, this is what will appear:


Graphics - [CURL_WELCOME - Modified]
File Edit View Insert Dynamic Tools Window Help
Sustainable Environment Simulator
Designed and Built by:
Team Curl: Robert Driggers, Martin de la Herran, Marlowe Quart
ROOM
Air Handler Unit
We are Team Curl!
Special Thanks to our Sponsor
SIEMENS

As one can see, there are two buttons, one that says “ROOM” and another one that says “AIR HANDLER UNIT”. As we explained earlier, our project consists of two parts, one is the control of all the variables of the room (temperature, CO2 level, fire alarm, humidity,…) and the other part is a simulator of the air handler unit of the whole building (shaped like an “H”). So we can either see one or the other by clicking on the buttons.

If we click on the “ROOM” button, we will see the following:


Graphics - [CURL_ROOM]
File Edit View Insert Dynamic Tools Window Help
THE ROOM
These are the readouts of our physical simulator that we are controlling in real time. The main controlling element in the room is the ATEC which primarially controls the VAV box. Below we have readouts of the many sensors we have hooked up in our room. Thank you.
Damper Position
ROOM:DMPR POS
ATEC
NORMAL
NONE
36.40 PCT
Room Temperature
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
ROOM:RM STPT DIAL 76.00
ROOM:ROOM TEMP 71.00
Heating/Cooling
ROOM:HEAT:COOL
ATEC
NORMAL
NONE
HEAT
Duct Temperature
ROOM:AI 4
ATEC
NORMAL
NONE
61.50 DEG F
Air Volume
ROOM:AIR VOLUME
ATEC
NORMAL
NONE
40.00 CFM
Heat Strip On/Off
ROOM:HEAT STAGE 1
ATEC
NORMAL
NONE
OFF
Occupied Sensor
AHU:DAMPERS:DI 2
NORMAL
NONE
ON
Special Thanks to our Sponsor
SIEMENS

We have now entered one of the display screens of the variables of the room. Here we can see that some of the values of the variables in the room are shown. In order to see this more clearly, we will take a closer look at each one of them:

Damper Position

Air Volume

“Damper position” refers to the damper that controls the amount of air that comes in the room. The most important part of these graphics is the bottom number of each one of them, the rest of the imformation on them tells us what they are and if they are functioning properly (where it says “normal”). The bottom number tells us in what percentage the damper is open, in this case it is open 38.40 percent, which means it is barely open.

In fact, if we take a look at the “air volume” box, we can see that the bottom number says 40 CFM (cubic feet per minute), which is the amount of air that is coming in the room, directly proportional to the percentage of opening of the damper.

Heating/Cooling

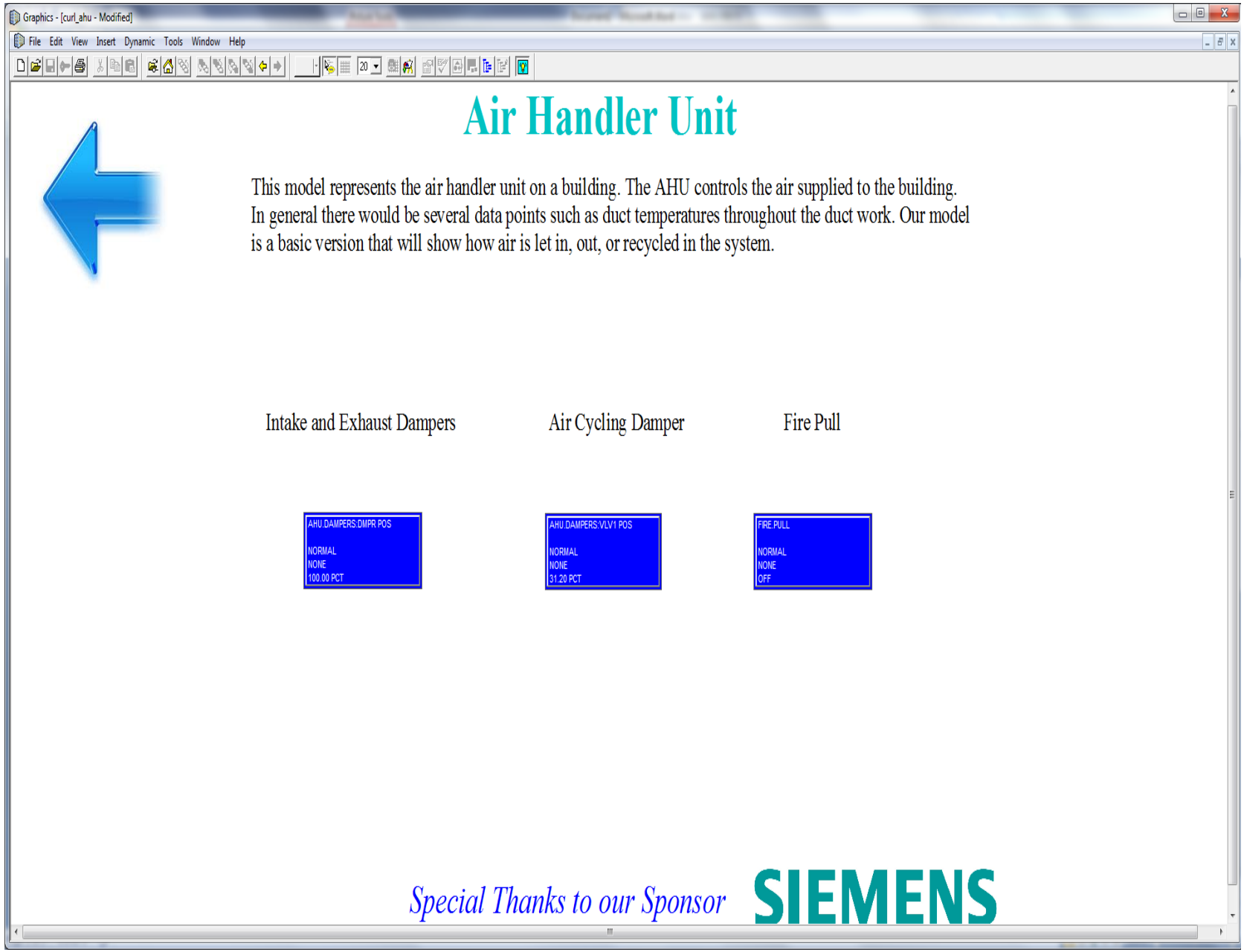
Duct Temperature

Heat Strip On/Off

Occupied Sensor

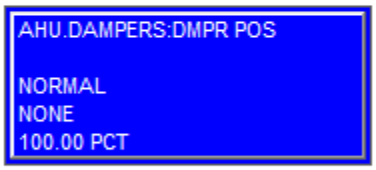
All of these graphics exept for the occupied sensor refer to the room temperature. The top-right box tells us if we are on a heating mode or a cooling mode. In this case, we are in a heating mode (as we can see on the last line). When we are on a heating mode, the heat strip, which we can control from the bottom-right box, will always we be on (as we can see on the last line of this box). The blue box is simply telling us what the temperature is right in the duct, where the air is coming from. Finally, the occupied sensor says “on” because it has detected people in the room.

If, intead of pressing the “ROOM” button, we pressed the “AIR HANDLER” button, this is what we would see:


Graphics - [curl_ahu - Modified]
File Edit View Insert Dynamic Tools Window Help
Air Handler Unit
This model represents the air handler unit on a building. The AHU controls the air supplied to the building. In general there would be several data points such as duct temperatures throughout the duct work. Our model is a basic version that will show how air is let in, out, or recycled in the system.
Intake and Exhaust Dampers
Air Cycling Damper
Fire Pull
AHU.DAMPERS:DMPR POS
NORMAL
NONE
100.00 PCT
AHU.DAMPERS:VLV1 POS
NORMAL
NONE
31.20 PCT
FIRE.PULL
NORMAL
NONE
OFF
Special Thanks to our Sponsor
SIEMENS

Here is a more clear image of each of these boxes:

Intake and Exhaust Dampers



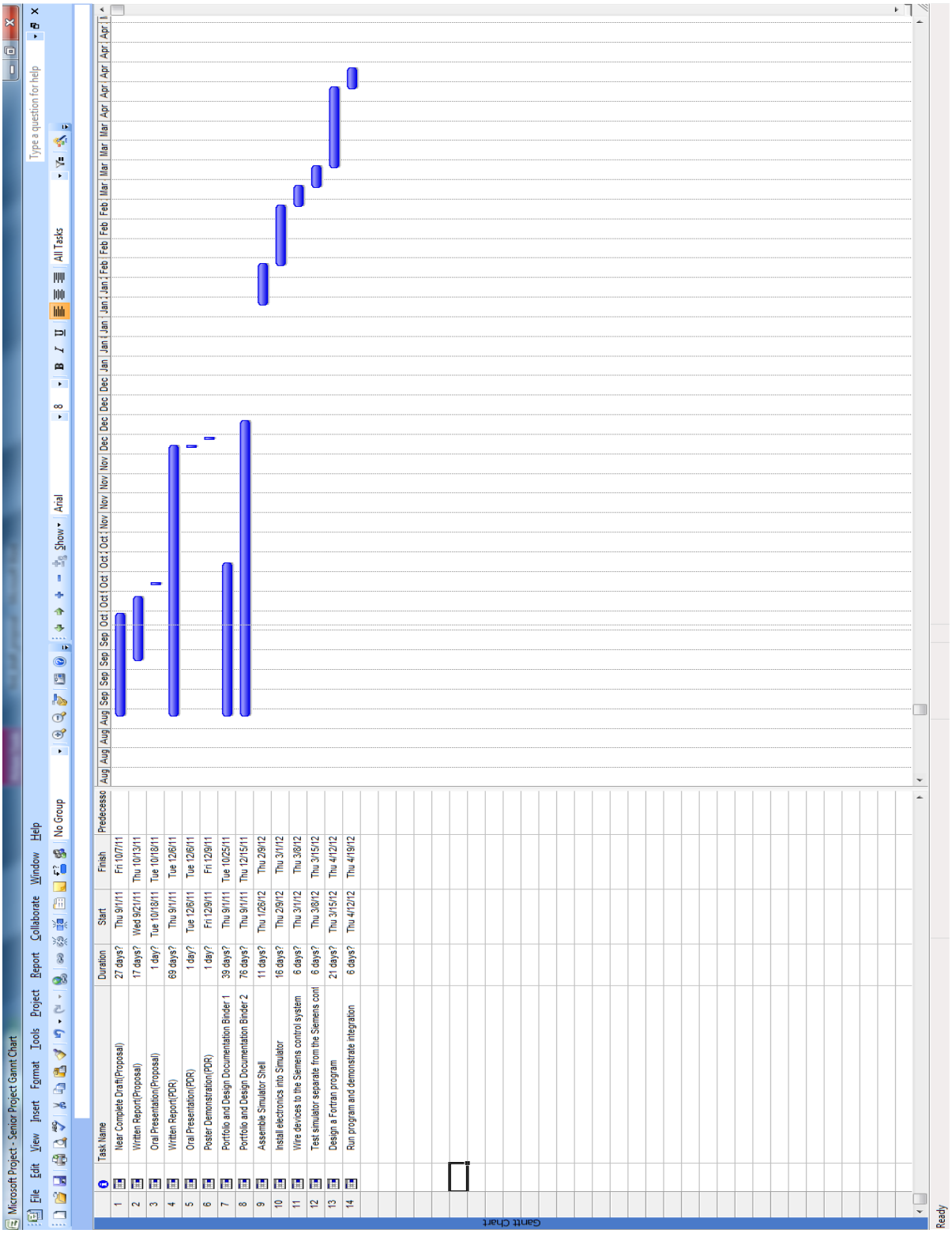
Air Cycling Damper

These two boxes indicate the percentage of opening of each of the three dampers. There are only two boxes for the three of them because the top and bottom dampers work together and always do the same thing, these are the intake and exhaust dampers. While one lets the air in, the other one lets the air out of the building, having to be open the same amount. In this case they are fully open (100 pct), which means that the air handler simulator is letting new air in the building. If we want to keep the air in the building cycling, without bringing any new air in, we will just have to close the intake and exhaust dampers and open the air cycling damper.

Fire Pull

This graphic simply indicates that the fire pull is properly connected and working well (where it says normal) and that it is off, so no one has pulled it. When we pull it, it turns to on and directly triggers the fire alarm and fire light.

8.6. Project Gantt Chart


Microsoft Project - Senior Project Gannt Chart
File Edit View Insert Format Tools Project Report Collaborate Window Help
Type a question for help
No Group
Arial
Show
All Tasks
Task Name
Duration
Start
Finish
Predecesso
1 Near Complete Draft(Proposal) 27 days? Thu 9/1/11 Fri 10/7/11
2 Written Report(Proposal) 17 days? Wed 9/21/11 Thu 10/13/11
3 Oral Presentation(Proposal) 1 day? Tue 10/18/11 Tue 10/18/11
4 Written Report(PDR) 69 days? Thu 9/1/11 Tue 12/6/11
5 Oral Presentation(PDR) 1 day? Tue 12/6/11 Tue 12/6/11
6 Poster Demonstration(PDR) 1 day? Fri 12/9/11 Fri 12/9/11
7 Portfolio and Design Documentation Binder 1 39 days? Thu 9/1/11 Tue 10/25/11
8 Portfolio and Design Documentation Binder 2 76 days? Thu 9/1/11 Thu 12/15/11
9 Assemble Simulator Shell 11 days? Thu 1/26/12 Thu 2/9/12
10 Install electronics into Simulator 16 days? Thu 2/9/12 Thu 3/1/12
11 Wire devices to the Siemens control system 6 days? Thu 3/1/12 Thu 3/8/12
12 Test simulator separate from the Siemens cont 6 days? Thu 3/8/12 Thu 3/15/12
13 Design a Fortran program 21 days? Thu 3/15/12 Thu 4/12/12
14 Run program and demonstrate integration 6 days? Thu 4/12/12 Thu 4/19/12
Gantt Chart
Ready

8.7. Wiring Summary (Summarized from Siemens' Wiring Manual)

Circuit Classes

There are three different classes of circuits that apply to building control system installations:

Class 1 Remote Control Circuits

Class 1 Power Limited Circuits

Class 2 Power Limited Circuits

Class 3 Power Limited Circuits

Class 1 Remote Control Circuits

Circuits not exceeding 600 volts, used for controlling equipment. Typically, this covers DO-type circuits used to control motors by energizing motor starters. These DO circuits are also used to control lights and other items through pilot devices such as relays or electro-pneumatic valves.

Class 1 Power Limited Circuits

Circuits not exceeding 30 volts and 1000VA. Typically, this covers power trunks.

Class 2 Power Limited Circuits

Circuits of relatively low power (such as 24 volts and up to 4 amps).

This covers the bulk of our circuits and includes the ALN communication wiring (Ethernet TCP/IP, P2/P3 RS-485, and MS/TP RS-485), all FLN bus wiring (P1 RS-485, LON, and MS/TP RS-485), 24 Vac power trunk wiring (with 100 VA power limit), and DI, AI, and AO circuits.

Class 3 Power Limited Circuits

Circuits of relatively low power but of higher voltage than Class 2 (such as 120 volts and up to 1 amp). This circuit would be achieved if 1 amp fuses were installed in a 120-volt DO-type circuit. This is not a common application.

Conduit Sharing—Class 1/Class 2 Separations

NOTE: Separate knockouts should be used for high voltage and low voltage wiring. Leave at least 2 inches (50.8 mm) of space between the Class 2 wires and other wires in the panel. (That is why we had class 1 wires in one box and class 2 wires in another one, see picutres of wired boxes at the end of project.)

Conduit sharing guidelines are based on the National Electrical Code (NEC) requirements that apply to the installation wiring of building automation systems.

All wire must have insulation rated for the highest voltage in the conduit and must be approved or listed for the intended application by agencies such as UL, CSA, FM, etc. Protective signaling circuits cannot share conduit with any other circuits.

Class 2 point wiring cannot share conduit with any Class 1 wiring except where local codes permit.

Where local codes permit, both Class 1 and Class 2 wiring can be run in the field panel enclosure, providing the Class 2 wire is UL listed 300V 75°C (167°F) or higher, or the Class 2 wire is NEC type CM (FT4) (75°C or higher) or CMP (FT6) (75°C or higher).

NEC type CL2 and CL2P is not acceptable unless UL listed for other type and rated for 300V 75°C (167°F) or higher.

All low voltage and high voltage wiring must be routed separately within an enclosure so that low voltage and high voltage wiring cannot come in contact with each other.

Conduit spacing

NOTE: Use cable tray spacing for non-metallic conduit.

The minimum distance between adjacent conduit runs.

The following guidelines reflect the recommendations given in IEEE 518-1982 for locating network wiring in proximity to sources of interference:

-For (ALN) trunk AIs, AOs, and DIs with circuits greater than 120 volts and carrying more than 20 amps:

Cable tray spacing = 26 in. (660.4 mm)

Cable tray and conduit spacing = 18 in. (457.2 mm)

Conduit spacing = 12 in. (304.8 mm)

-For circuits greater than 1000 volts or greater than 800 amps:

Cable tray spacing = 5 ft (1.5 m)

Cable tray and conduit spacing = 5 ft (1.5 m)

Conduit spacing = 2.5 ft (0.8 m)

Conduit Fill

All wire must have insulation rated for the highest voltage in the conduit and must be approved or listed for the intended application by agencies such as UL, CSA, FM, etc.

The following tables contain wire specifications. For more information, see Circuit Classes and Conduit Sharing–Class1/Class2 Separations in this chapter and Using Existing Wiring in Chapter 2.

Cables per Conduit Size – Siemens Industry Recommendation

Siemens Industry recommends a 40 percent conduit fill. Use the following table to determine the number of cables (twisted pairs and twisted shielded pairs) per conduit size at 40% fill. Plenum wiring can be used in place of any low voltage wiring without changes to length. The Field Purchasing Guide lists the outside diameter for each cable. Table 1. Conduit Fill.

Outside Diameter*				Quantity in Conduit at 40% Fill	
1/2" (12.7 mm)	3/4" (19.1 mm)	1" (25.4 mm)	1 1/4" (31.8 mm)	1 1/2" (38.1 mm)	2" (50.8 mm)
0.325" (8.255 mm)	1	3	4	7	10	16
0.3" (7.62 mm)	2	3	5	8	12	19
0.25" (6.35 mm)	2	4	7	12	17	27
0.225" (5.715 mm)	3	5	9	15	20	34
0.2" (5.08 mm)	4	7	11	19	26	43
0.175" (4.445 mm)	5	9	14	25	34	56
0.15" (3.81 mm)	7	12	20	34	46	76
0.125" (3.175 mm)	10	17	28	49	66	109

* Plenum-rated cable generally has a smaller diameter than equivalent non-plenum types. Check specific product tables in this chapter for specific applications where plenum cable must be used in conduit.

Cables per Conduit Size—NEC Requirements

NEC allowable conduit fill is 53 percent for 1 conductor, 31 percent for 2 conductors, and 40 percent for 3 or more conductors. Use the following table to determine the number of cables (twisted pairs and twisted shielded pairs) per conduit size in accordance with NEC fill requirements. The Field Purchasing Guide lists the outside diameter for each cable.

Protective signaling circuits cannot share conduit with any other circuits.

Class 2 circuits cannot share conduit with Class 1 circuits except as noted.

23 Siemens Industry, Inc. APOGEE Wiring Guidelines for Field Panels and Equipment Controllers 125-3002, Rev 8 6/4/2010Chapter 1—Wiring Regulations and Specifications Table 2. Conduit Fill—NEC Requirements.							
Nominal Insulated Conductor		Conduit Nominal I.D. Area				Quantity in Conduit 2	
O.D. (inches) 1	Conductor Area (sq. in.)	1/2“ EMT 0.622 0.304	3/4“ EMT 0.824 0.533	1“ EMT 1.049 0.864	1-1/4" EMT 1.380 1.496	1-1/2" EMT 1.610 2.036	2" EMT 2.067 3.356
0.400	0.126	1	1	2	5	6	10
0.390	0.119	1	1	3	5	7	11
0.380	0.113	1	1	3	5	7	12
0.370	0.108	1	1	3	5	7	12
0.360	0.102	1	1	3	6	8	13
0.350	0.096	1	1	3	6	8	14
0.340	0.091	1	2	4	6	9	15
0.330	0.086	1	2	4	7	9	15
0.320	0.080	1	2	4	7	10	16
0.310	0.075	1	3	4	8	11	18
0.300	0.071	1	3	5	8	11	19
0.295	0.068	1	3	5	8	12	19
0.290	0.066	1	3	5	9	12	20
0.285	0.064	1	3	5	9	13	21
0.280	0.062	1	3	5	9	13	22
0.275	0.059	1	3	6	10	13	22
0.265	0.055	1	4	6	11	15	24
0.255	0.051	2	4	7	11	16	26
0.245	0.047	2	4	7	12	17	28
0.235	0.043	3	5	8	14	19	31
0.225	0.040	3	5	8	15	20	33
0.215	0.036	3	6	9	16	22	37
0.205	0.033	3	6	10	18	24	40
0.195	0.030	4	7	11	20	27	45
0.185	0.027	4	8	13	22	30	50
0.175	0.024	5	9	14	25	34	56

0.165	0.021	5	10	16	28	38	63
0.155	0.019	6	11	18	31	43	71
0.145	0.017	7	13	21	36	49	81
0.135	0.014	8	15	24	42	57	94
0.125	0.012	10	17	28	48	66	109
0.115	0.010	11	20	33	57	78	129
0.105	0.009	14	24	40	69	94	155
0.095	0.007	17	30	49	84	115	189
0.085	0.006	21	37	61	105	143	236
0.075	0.004	27	48	78	135	184	304
0.065	0.003	36	64	104	180	245	404

1)	Plenum rated cable generally has a smaller diameter than equivalent non-plenum types. Check the tables in this section for specific applications where plenum cable must be used in conduit.
2)	Based on NEC guidelines. Allowable fill: 53% for 1 conductor, 31% for 2 conductors, and 40% for 3 or more conductors.

Controlling Transients

Any sensor or communication wiring that is exiting a building must have transient protection; effective protection requires proper wiring (grounding). Where protection is needed, use the parts listed in the following table. Table 3. MOV Part Numbers.

Part Number	Description	Application
540-248	MOV (3)60V Ipk 1200 amp	(25 pack) 3 MOV pre-twisted for use on 24 Vac 3-wire power terminals.
540-249	RC Snubber 600V .1µF, 1 Kilohm	(25 pack) Snubber with #10 screw lug and ¼ inch spade terminals for use across connector coil in VAV boxes.

550-809 P10	MOV 60V Ipk 4500A	(10 pack) MOV with ¼ inch spade terminals for use across flow switch power in VAV boxes.

8.8 Power Budget

We have calculated the maximum power and minimum power in Watts using the limitations that were written in the manuals for each device:

Fire alarm light (on strobe setting 15): P(max) = 33 V x 0.069 A (DC) or P(24v) = 24 V x 0.069 A (DC)

Terminal Box Controller (540-100 FLN BOX): 4 VA @ 24 V ac max.

Duct Temperature sensor (536-811): 10,000 ohms or 100,000 ohms

Room Temperature Sensors (540-680FB): 8.6 mW maximum

Standard Room Temp Sensor (QAA2072): 0 to 10V, 4 to 20 mA

Humidity Sensor (QFA3171D): <1 VA

CO2 Sensor (QPA2000): ≤2 VA

Transformer (120/24): 100 VA Rating

PXC Controller: 24 VA

TX Moduls: (see under image)

TXM1.8D 1.1 W

TXM1.16D 1.4 W

TXM1.8U 1.5 W

TXM1.8U-ML 1.8 W

TXM1.8X 2.2 W

TXM1.8X-ML 2.3 W

TXM1.6R 1.7 W

TXM1.6R-M 1.9 W

Total consumption for top box:

+ Transformer: 100 VA

+ 3 actuators: 12 VA

+ ATEC temp sensor: 10,000 ohms or 100,000 ohms (Pmax = V*V/Rmin = 24*24/10,000 = 0.0576W)

+ heat strip: 125 W

+ relay: 0 (approx.)

Total Max Power (power factor=1) for top box = 100 + 12*3 + 0.0576 + 125 + 0 = **261.0576 W**

Total Min Power (power factor=.75) for top box = 100 * 0.75 + (12*0.75)*3 + 0.0576 + 125 + 0 = **227.0576 W**

Total Consumption for bottom box:

+ TXM1.8D 1.1 W

+ TXM1.16D 1.4 W

+ TXM1.8U 1.5 W

+ TXM1.8U-ML 1.8 W

+ TXM1.8X 2.2 W
+ TXM1.8X-ML 2.3 W
+ TXM1.6R 1.7 W
+ TXM1.6R-M 1.9 W
+ PXC Controller: 24VA
+ Fire alarm light (on strobe setting 15): P(24v) = 24 V x 0.069 A (DC) = 1.656 VA
+ Terminal Box Controller (540-100 FLN BOX): 4 VA
+ Room Temperature Sensors (540-680FB): 8.6 mW maximum
+ Standard Room Temp Sensor (QAA2072): Pmax = 10 V * 0.02 A = 0.2 VA
+ Humidity Sensor (QFA3171D): <1 VA
+ CO2 Sensor (QPA2000): ≤2 VA

Total Max power (Power Factor = 1) for bottom box = **46.7646 W**

Total Min Power (Power Factor = 0.75) for bottom box = **38.5506 W**

TOTAL POWER CONSUMPTION (top box + bottom box):

P MAX = 261.0576 + 46.7646 = 307.8222 W

P MIN = 227.0576 + 38.5506 = 265.6082 W

8.9 Spec Sheets

QPA Series

Room Carbon Dioxide Sensors

QPA2060D Q Series
Room Carbon Dioxide & Temperature Sensor.

Energy & Atmosphere

Indoor Environmental Quality

Description

The QPA Series Room Carbon Dioxide Sensors monitor and transmit changes in CO_2 to the building control systems. No calibration of the CO_2 sensor is necessary — these microprocessor-based units consist of a non-dispersive infrared CO_2 sensor that experiences less than 1% drift per year for the first two years of operation and negligible drift thereafter. All variants for CO_2 and combination versions with Temperature or VOC deliver 0 to 10 Volt proportional signals to the controller.

Applications

These units are especially suited for applications where precise, stable CO_2 sensing is required.

Features

- LCD display option
- Various models:
  CO_2
  CO_2/VOC
  CO_2/Temp
  CO_2/Temp/RH
- Built-in test function for troubleshooting
- Jumper selectable °C/°F units for temp models w/display
- No Logo versions available

B-25

Sensors

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QPA Series Specifications

General

Installation ..... 18 AWG cable length shared in conduit with other sensor wiring 750 ft. (229 m) max
Connections ..... Screw terminals
Dimensions ..... 3.94" H x 3.54" W x 1.65" D (100 mm x 90 mm x 42 mm)
Voltage Requirement ..... 13.5 to 35 Vdc
Housing Protection Class ..... NEMA 1 (all types)

CO_2 Element

Operating Range ..... 0 - 2000 ppm
Accuracy at Room Temperature ≈ 73°F (20°C) ..... +2% mV
Operating Temperature ..... -23 to +113°F (-5 to +45°C)
Temperature Effect ..... Less than 0.1% per degree C
Sensing Element ..... NDIR CO_2 sensing module
Output Signal ..... 0 to 10 Vdc, 0-100% Linear, Proportional
Polarity Protection ..... Yes
Permissible Air Velocity in the Room ..... <26.2 ft./s

Temperature Element (for Combination CO_2/T unit only)

Operating Temperature ..... 23 to 113°F (-5 to 45°C)
Time Constant ..... <1 minute
Accuracy ..... ±0.8K
Output Signal ..... 0-10 volts
Calibration ..... None Required

Humidity Element

Measuring Range ..... 0 to 100% RH
Accuracy ..... ±5% RH

QPA Series Product Ordering

Application	Description	Part No.
Room Sensor, CO2	0 to 10 V	QPA2000
Room Sensor, CO2	0 to 10 V, No Logo	QPA2000N
Room Sensor, CO2 and VOC	0 to 10 V	QPA2002
Room Sensor, CO2 and VOC	0 to 10 V, with Display	QPA2002D
Room Sensor, CO2 and VOC	0 to 10 V, No Logo	QPA2002N
Room Sensor, CO2 and Temp	0 to 10 V	QPA2060
Room Sensor, CO2 and Temp	0 to 10 V, with Display	QPA2060D
Room Sensor, CO2 and Temp	0 to 10 V, No Logo	QPA2060N
Room Sensor, CO2, Temp and RH	0 to 10 V	QPA2062
Room Sensor, CO2, Temp and RH	0 to 10 V, with Display	QPA2062D

Accessories & Service Kits B-35

QFA Series

Room Relative Humidity and Relative Humidity/Temperature Sensors

QFA Series Room Relative Humidity and Relative Humidity/Temperature Sensor.

QFA Series Room Relative Humidity and Relative Humidity/Temperature Sensor.

Energy & Atmosphere

Indoor Environmental Quality

Description

The QFA Series Room Relative Humidity and Relative Humidity/Temperature Sensors monitor and transmit changes in humidity and temperature to the building control systems.

Several models are available for humidity only (in 5% and 2%) or for humidity and temperature sensing (also in 5% and 2% versions). The humidity only units are available in either 4 to 20 mA or 0 to 10 Volt signal versions. Combination humidity and temperature units are available in either dual current or voltage versions, transmitting proportional signals back to the controller.

Applications

These units are especially suited for applications where precise, stable humidity sensing is required.

Features

Standard Features

- 4 to 20 mA and 0 to 10 Vdc output signals
- High degree of accuracy

Full-featured Models

- Liquid Crystal Display (LCD in degrees F or C)
- Digital Temperature Setpoint Adjustment in 0.5 degree increments
- Override Button
- Removable, replaceable humidity element (2% versions only)

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QFA Series Specifications

General

Installation.....18 AWG Cable Length Shared in Conduit with Other Sensor Wiring 750 ft. (229 m) Max
Connections.....Screw Terminals
Voltage Requirement.....13.5 to 35 Vdc and 24 Vac (for sensors with 0-10 Vdc outputs)
CE and UL listed.....UL 873 Standard for Temperature Indicating and Regulating Equipment

Housing
Material Type.....Polycarbonate Plastic
Color.....Desert Beige or White
Dimensions.....3-11/32" H x 2-1/2" W x 1-1/2" D (85 mm H x 63 mm W x 38 mm D)

Operating Range.....0 to 100% RH
Measurement Range.....0 to 100% RH
Accuracy at room temperature (73°F, 20°C).....±5% RH for 0% ≤ RH < 30% or 70% ≤ RH < 95%
±3% RH for 30% ≤ RH < 70%
Operating Temperature.....-31 to +140°F (-35 to +60°C)
Temperature Effect.....Less than 0.1% per Degree C
Sensing Element.....Capacitive Humidity Sensing Element
Output Signal.....4 to 20 mA or 0 to 10 Vdc, 0 to 100% Linear, Proportional
Polarity Protection.....Yes

Humidity Element

Temperature Element (for combination RH/T units only)
Operating Temperature.....32 to 122°F (0 to 50°C)
Time Constant at 0 to 50°C and 10-80%RH.....Approx. 20 Seconds in Moving Air
Accuracy.....at 32 to 122°F (0 to 50°C): ±1 K
at -31 to +95°F (-35 to +35°C): ±0.8 K
at -31 to +140°F (-35 to +60°C): ±1 K
Output Signal.....4 to 20 mA or 0 to 10 Vdc, 0 to 100% Linear, Proportional, (Terminal U2)
Calibration Adjustments.....None

QFA Series Product Ordering

Application	Description	Part No.
Room Relative Humidity 5%	0 to 10 Vdc, No LCD, Beige	QFA2000.BU
Room Relative Humidity 5%	0 to 10 Vdc, No LCD, White	QFA2000.WU
Room Relative Humidity 5%	4 to 20 mA, No LCD, Beige	QFA2001.BU
Room Relative Humidity 5%	4 to 20 mA, No LCD, White	QFA2001.WU
Room Relative Humidity 5% & Temperature	0 to 10 Vdc, No LCD, Beige	QFA2060.BU
Room Relative Humidity 5% & Temperature	0 to 10 Vdc, No LCD, White	QFA2060.WU
Room Relative Humidity 5% & Temperature	0 to 10 Vdc, LCD, Temp Setpoint, Occupant Override, Beige	QFA2060.FBU
Room Relative Humidity 5% & Temperature	0 to 10 Vdc, LCD, Temp Setpoint, Occupant Override, White	QFA2060.FWU
Room Relative Humidity 5% & Temperature	4 to 20 mA, No LCD, Beige	QFA2071.BU
Room Relative Humidity 5% & Temperature	4 to 20 mA, No LCD, White	QFA2071.WU
Room Relative Humidity 5% & Temperature	4 to 20 mA, LCD, Temp Setpoint, Occupant Override, Beige	QFA2071.FBU
Room Relative Humidity 5% & Temperature	4 to 20 mA, LCD, Temp Setpoint, Occupant Override, White	QFA2071.FWU
Room Relative Humidity 2%	0 to 10 Vdc, No LCD, Beige	QFA3000.BU
Room Relative Humidity 2%	0 to 10 Vdc, No LCD, White	QFA3000.WU
Room Relative Humidity 2%	4 to 20 mA, No LCD, Beige	QFA3001.BU
Room Relative Humidity 2%	4 to 20 mA, No LCD, White	QFA3001.WU
Room Relative Humidity 2% & Temperature	0 to 10 Vdc, No LCD, Beige	QFA3060.BU
Room Relative Humidity 2% & Temperature	0 to 10 Vdc, No LCD, White	QFA3060.WU
Room Relative Humidity 2% & Temperature	0 to 10 Vdc, LCD, Temp Setpoint, Occupant Override, Beige	QFA3060.FBU
Room Relative Humidity 2% & Temperature	0 to 10 Vdc, LCD, Temp Setpoint, Occupant Override, White	QFA3060.FWU
Room Relative Humidity 2% & Temperature	4 to 20 mA, No LCD, Beige	QFA3071.BU
Room Relative Humidity 2% & Temperature	4 to 20 mA, No LCD, White	QFA3071.WU
Room Relative Humidity 2% & Temperature	4 to 20 mA, LCD, Temp Setpoint, Occupant Override, Beige	QFA3071.FBU
Room Relative Humidity 2% & Temperature	4 to 20 mA, LCD, Temp Setpoint, Occupant Override, White	QFA3071.FWU

SIEMENS

Technical Specification Sheet
Rev. 3, April, 2004

ATEC Base VAV Controller & ATEC VAV Reheat Controller

Description

The new ATEC (Actuating Terminal Equipment Controller) Variable Air Volume Controllers provide direct digital control of pressure-independent, variable-air-volume zone-level routines. The ATEC controllers can operate stand-alone or can be networked to perform complex HVAC control, monitoring and energy management functions. The ATEC controllers are designed to reside on the Siemens Building Technologies APOGEE® Building Automation System.

Features

- Controller integrated with actuator for ease of installation;
- Automated checkout procedure for ease of startup/commissioning and troubleshooting;
- PID control of HVAC systems to minimize offset and maintain tighter set point control;
- HVAC diagnostic capability at the BLN level using the TBC Test Tool in CT 4.8;
- ATEC Base VAV Controller requires only 3.5 VA, an advantage when sizing electrical capacity;
- Suitable for installation in plenum areas;
- Set points and control parameters assigned and changed locally or remotely;
- Electrically Erasable Programmable Read Only Memory (EEPROM) used for storing set points and control parameters—no battery backup required;
- Return from power failure without operator intervention;
- Uses proven APOGEE Automation System DDC architecture;
- No calibration required, thereby reducing maintenance costs.

Applications

Operating independently, or as part of the APOGEE Building Automation System, the ATEC VAV Controller can control the following VAV pressure-independent zone applications.

ATEC Base VAV Controller:

- VAV Cooling Only (application 2520—similar to 2020 for the ATEC);
- VAV Cooling or Heating (application 2521—similar 2021).
- Slave Mode (application 2486)

ATEC VAV with Reheat Controller:

- VAV Cooling Only (application 2500—similar to 2020);
- VAV Cooling or Heating (application 2501—similar to 2021);

- VAV with Electric Reheat or Baseboard Radiation (application 2522—similar to 2022);
- VAV with Hot Water Reheat (only one reheat valve) (application 2523—similar to 2023 with one reheat valve);
- VAV Series Fan Powered with one stage of Electric Reheat (application 2524—similar to 2024 with one stage of electric reheat);
- VAV Parallel Fan Powered with one stage of Electric Reheat (application 2526—similar to 2026 with one stage of electric reheat);
- Slave Mode (application 2473).

Control algorithms are preprogrammed. The controller is ready to operate after selecting the application and assigning the unit's controller address. If desired, the operator may adjust the air volume set points in cfm (l/s), room temperature set points, and other parameters. The controller is designed for operation and modification without vendor assistance.

Hardware

Controller Board

The ATEC consists of an electronic controller, a differential pressure transducer, and a damper actuator assembly. This controller provides all wiring terminations for system and local communication and power. The cable from the room sensor (purchased separately) connects to an RJ-11 jack on the controller. All other connections are removable terminal blocks.

The ATEC Base VAV Controller has no external, wireable I/O. The ATEC VAV with Reheat Controller, however, has additional I/O: 2 AI/DIs and 2 DOs.

In addition to controlling the integrated damper actuator, the controller interfaces with the following external devices (purchased separately):

- Averaging air velocity sensor provided by VAV terminal unit manufacturers;
- Room temperature sensor with optional set point dial and night override button;
- Service and commissioning tools;
- APOGEE Building Automation System.

Room Sensor

The room sensor connection to the controller board consists of a quick-connect RJ-11 jack. This streamlines the installation and reduces the ATEC's start-up time. See the Room Temperature Sensors Technical Specification Sheet, P/N 149-312P25, for more information.

Differential Pressure Sensor

The Differential Pressure Sensor (purchased separately) is easily connected to the box's air-velocity sensing elements to provide measurement of the differential pressure. The measured value is converted to actual airflow in cfm (l/s) by the ATEC controller.

Specifications

Controller & Actuator		
Power Requirements:	Base:	Reheat:
Power Source	24 Vac +/- 15%	24 Vac +/- 15%
Frequency	50/60 Hz	50/60 Hz
Power Consumption	3.5 VA	3.5 VA plus loads
Operating Temperature Range	+32°F to +122°F (0°C to +50°C)	
Storage Temperature Range	-20°F to +140°F (-29°C to +60°C)	
Humidity Range	10% to 95% non-condensing	
Regulatory Compliance	UL/CUL 916 PAZX/PAZX7 (Enclosed Energy Management) FCC Part 15, Class B CSA-Std. C22.2 No 205 CE Mark; C-Tick	
Dimensions	5-9/16"H x 2-15/16"W x 4-3/16"D (142 mm x 75 mm x 106 mm)	
Weight	1.26 lbs (.572 kg)	
Actuator Torque	44 lb.-in. (5Nm)	
Run time for 90° opening or closing at:		
50 Hz	108 sec.	
60 Hz	90 sec.	
Nom. Angle of Rotation	90°	
Max. Angle of Rotation	95°	
Actuator Shaft Size	3/8" to 5/8" (8 to 16 mm) Dia ¼" to ½" (6 to 13 mm) Sq.	
Minimum Shaft Length	¾" (20 mm)	

Transformer Requirements and Recommended Voltages

Type	Class 2, 24 VAC, 50/60 Hz, SELV, PELV

Ordering Information

Controllers	
Description	**Product Number**
ATEC Base VAV Controller	550-400
ATEC Base VAV Controller—10 pack	550-400P10
1 AVS Air Velocity Sensor (0—5,664 FPM)	
1 RS Tool/10 K Ω Thermistor Room Sensor Module Connection Port	
ATEC VAV with Reheat Controller	550-405
ATEC VAV with Reheat Controller—10 pack	550-405P10
2 AI/DI 100 K Ω Thermistor or Dry Contact	
2 DO 12 VA, 24Vac Triac	
1 AVS Air Velocity Sensor (0—5,664 FPM)	
1 RS Tool/10 K Ω Thermistor Room Sensor Module Connection Port	
Documentation	**Product Number**
ATEC Owner's Manual	125-3209
Room Temperature Sensors Technical Specification Sheet	149-312P25

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SIEMENS

Technical Specification Sheet
Document No.149-478
Rev. 3.0, January 2008

PXC Modular Series

Figure 1. PXC Modular.

Description

The PXC Modular (Programmable Controller - Modular) is an integral part of the APOGEE® Automation System. It is a high performance, modular Direct Digital Control (DDC) supervisory field panel.

The field panel operates stand-alone or networked to perform complex control, monitoring, and energy management functions without relying on a higher level processor.

- Up to 100 modular field panels communicate on a peer-to-peer network.
- With the addition of TX-I/O modules and a TX-I/O Power Supply on a self-forming bus, the PXC Modular can directly control up to 500 points.

With the addition of an Expansion Module, the PXC Modular also provides central monitoring and control for distributed Field Level Network (FLN) devices.

Features

- Modular hardware components match initial control requirements while providing for future expansion.
- DIN rail mounting and removable terminal blocks simplify installation and servicing.
- Proven program sequences to match equipment control applications.
- Sophisticated Adaptive Control, a closed loop control algorithm that auto-adjusts to compensate for load/seasonal changes.
- Built-in energy management applications and DDC programs for complete facility management.
- Comprehensive alarm management, historical data trend collection, operator control and monitoring functions.
- Support for peer-to-peer communications over Industry standard 10/100Base-T TCP/IP networks.

Hardware

PXC Modular

- The PXC Modular is a microprocessor-based multi-tasking platform for program execution and communication with other field panels. It scans field data, optimizes control parameters, and manages operator requests for data in seconds.
- The program and database information stored in the PXC Modular memory is battery-backed. This eliminates the need for time-consuming program and database re-entry in the event of an extended power failure. When battery replacement is necessary, the PXC Modular illuminates a "battery low" status LED and can send an alarm message to selected printers or terminals.
- The PXC Modular firmware, including the operating system, is stored in non-volatile flash memory.
- The PXC Modular provides both an Ethernet port as well as an RS-485 port for communication on Automation Level Networks using either TCP/IP or RS-485.
- An HMI RS-232 port is provided as a connection to a laptop computer for local operation and engineering.
- LEDs provide instant visual indication of overall operation, network communication, and low battery warning.
- Two self-forming buses are an integral part of the flexibility of the PXC Modular. A self-forming bus to the right of the controller supports up to 500 points through TX-I/O™ modules. Another self-forming bus to the left of the controller supports hardware connection to subsystems through Expansion Modules.

TX-I/O Modules

TX-I/O Modules are modular expansion I/O consisting of an electronics module and terminal base. The electronics modules perform A/D or D/A conversion, signal processing, and point monitoring and command output through communication with the PXC Modular. The terminal bases provide for termination of field wiring and connection of a self-forming bus. For more information, see *TX-I/O* (149-476).

The TX-I/O Power Supply provides power for TX-I/O modules and peripheral devices. Multiple Power Modules can be used in parallel to meet the power needs of large concentrations of I/O points (Figure 2 and Figure 3). For more information, see *TX-I/O Power Supplies* (149-476).

Figure 2. TX-I/O Power Supply and TX-I/O Modules.

Figure 3. PXC Modular, TX-I/O Power Supply, and TX-I/O Modules.

PXC Modular Expansion Module

The PXC Modular Expansion Module (see Figure 4) provides the hardware connection for Field Level Network (FLN) devices. Using the Triple RS-485 Expansion Module, the PXC Modular supports up to three RS-485 networks of Field Level Network devices (see Figure 5).

Figure 4. RS-485 Expansion Module.

Figure 5. RS-485 Expansion Module and PXC Modular.

Modular Control Panels with Application Flexibility

The PXC Modular is a high performance controller with extensive flexibility to customize each field panel with the exact hardware and program for the application. As a result, the user only purchases what is needed.

For example, in monitoring applications, the control panel can be customized with the number and type of points to match the sensor devices. For monitoring and controlling a large number of (on-off) fans or

motors, more digital points can be added (see Figure 6).

Figure 6. PXC Modular, TX-I/O Power Supply, and TX-I/O Modules.

Alternately, if no local point control is required, the PXC Modular can be used to monitor and control Field Level Network devices using the Expansion Modules (see Figure 7).

Figure 7. RS-485 Expansion Module and PXC Modular.

Of course, the PXC Modular can be used for both direct point monitoring and control **and** as a system controller for Field Level Network devices (see Figure 8).

Figure 8. RS-485 Expansion Module, PXC Modular, TX-I/O Power Supply, and TX-I/O Modules.

The control program for each field panel is customized to exactly match the application. Proven Powers Process Control Language (PPCL), a "BASIC" type programming language, provides direct digital control and energy management sequences to precisely control equipment and optimize energy usage.

In a stand-alone configuration, the PXC Modular can fulfill all requirements of a supervisory network coordinator by managing operation schedules and alarms and communicating for the connected devices.

Global Information Access

Each PXC Modular is equipped with an RS-232 port. This port supports the connection of a computer. Devices connected to the terminal port gain global information access.

Multiple Operator Access

Multiple operators can access the network simultaneously. When using the Ethernet ALN option, multiple operators may access the controller through concurrent Telnet sessions and/or local operator terminal ports.

Menu Prompted, English Language Operator Interface

The PXC Modular field panel includes a simple, yet powerful menu driven English Language Operator Interface that provides, among other things:

- Point monitoring and display
- Point commanding
- Historical trend collection and display for multiple points
- Equipment scheduling
- Program editing and modification via Powers Process Control Language (PPCL)
- Alarm reporting and acknowledgment
- Continual display of dynamic information

Built-in Direct Digital Control Routines

The PXC Modular provides stand-alone Direct Digital Control (DDC) to deliver precise HVAC control and comprehensive information about system operation. It receives information from sensors in the building, processes the information, and directly controls the equipment. The following functions are available in the PXC Modular:

- Adaptive Control, an auto-adjusting closed loop control algorithm. Provides more efficient, adaptive, robust, fast, and stable control than the traditional PID control algorithm. Superior in terms of response time, holding steady state, and minimizing error, oscillations, and actuator repositioning.
- Closed Loop Proportional, Integral and Derivative (PID) control.
- Logical sequencing.
- Alarm detection and reporting.
- Reset schedules.

Built-in Energy Management Applications

The following applications are programmed in the PXC Modular and require simple parameter input for implementation:

- Peak demand limiting
- Start-Stop time optimization
- Equipment scheduling, optimization and sequencing
- Duty cycling
- Economizer control

Licensable Options

The following features are available on the PXC Modular P2 controllers and require a license for implementation:

- Field Panel GO
- Virtual AEM

Specifications

Dimensions

PXC Modular Series	7.56" L × 3.54" W × 2.76" D (192 mm L × 90 mm W × 70 mm D)
Expansion Module with three P1 RS-485 FLN connections	1.26" L × 3.54" W × 2.76" D (32 mm L × 90 mm W × 70 mm D)

Electrical, Processor, Battery, and Memory

Power Consumption	24 VA @ 24 Vac
Processor	MPC885 (PowerPC®)
Processor Clock Speed	133 MHz
Memory	72 MB (64 MB SDRAM, 8 MB Flash ROM)
Secure Digital Input/Output (SDIO) card	Expandable or removable non-volatile memory
Battery backup of SDRAM	30 days (accumulated) AA (LR6) 1.5 Volt Alkaline (non-rechargeable)
Battery backup of Real Time Clock	12 months (accumulated) Cell coin 3 Volt lithium

Communication

Ethernet Automation Level Network (EALN) port BACnet I/P Ethernet Automation Level Network port	10Base-T or 100Base-TX compilant
RS-485 Automation Level Network (ALN) port	1200 bps to 115.2 Kbps
Expansion Bus for support of sub-system networks	1200 bps to 115.2 Kbps
TX-I/O Self forming bus connection	115.2 Kbps
Human-Machine Interface (HMI) port	RS-232 compliant
USB Device Port	Standard 1.1 and 2.0 USB device port, full speed 12 Mbps, low speed 1.5 Mbps, Type B connector
USB Host port	Standard 1.1 and 2.0 USB host port, full speed 12 Mbps, low speed 1.5 Mbps, Type A connector

Electrical Rating

AC Power	NEC Class 2
Communication	NEC Class 2

Operating Environment

Ambient operating temperature	32°F to 122°F (0°C to 50°C), <93% rh, non-condensing
Ambient operating environment	Operate in a dry location, which is protected from exposure to salt spray or other corrosive elements. Exposure to flammable or explosive vapors must be prevented.
Shipping and Storage environment	-40°F to +185°F (-40°C to +85°C) <93% rh, non-condensing
Shipping environment	-13°F to 158°F (-25°C to 70°C), 5% to 95% rh, non-condensing
Mounting Surface	Building wall or structural member

Agency Listings

UL	UL 864 UUKL Smoke Control Equipment UL 864 UUKL7 Smoke Control Equipment CAN/ULC-S527-M8 UL 916 PAZX UL 916 PAZX7
Agency Compliance	FCC Compliance Australian EMC Framework European EMC Directive (CE) – with enclosure

Product Ordering Information

Description	Product Number
PXC MOD, P2, 96 NODE, APOGEE	PXC00-PE96.A
PXC MOD, P2, TX-I/O, 96 NODE, APOGEE	PXC100-PE96.A
PXC MOD, BACnet, 96 NODE, APOGEE	PXC00-E96.A
PXC MOD, BACnet, TX-I/O, 96 NODE, APOGEE	PXC100-E96.A
Add support for TX-I/O	PXF-TXIO.A
Virtual AEM License	LSM-VAEM
Field Panel GO License	LSM-FPGO
Expansion Module, three RS-485 connections	PXX-485.3

Document Ordering Information

Description	Document Number
PXC Modular Series Owner's Manual	125-3582
Powers Process Control Language (PPCL) User's Manual	125-1896

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Country of Origin: US
Document No. 149-478
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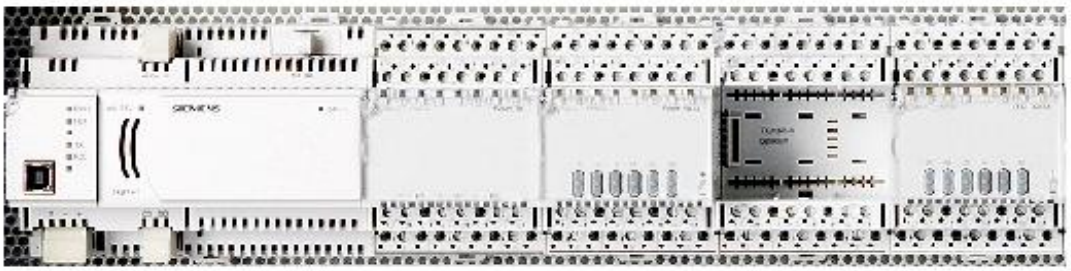
SIEMENS

Technical Specification Sheet
Document No. 149-476
January 24, 2007

TX-I/O Product Range



Description

TX-I/O™ is a line of I/O modules with associated power and communication modules for use within the APOGEE system. TX-I/O products include eight types of I/O modules, modular TX-I/O Power Supplies, Bus Connection Modules, and Bus Interface Modules.

TX-I/O Modules provide I/O points for APOGEE based upon TX-I/O Technology. TX-I/O Technology provides flexibility of point types, tremendous flexibility of signal types and support for manual operation.

There are eight types of TX-I/O modules:

- 8 point DI module (TXM1.8D)
- 16 point DI module (TXM1.16D)
- 6 point DO with Relay module (TXM1.6R)
- 6 point DO with Relay and Manual Override module (TXM1.6R-M)
- 8 point Universal module (TXM1.8U)
- 8 point Universal with local override/identification device (LOID) module (TXM1.8U-ML)
- 8 point Super Universal module (TXM1.8X)
- 8 point Super Universal with LOID module (TXM1.8X-ML)

Features

The *self-forming TX-I/O bus* transmits power as well as communication signals. The TX-I/O bus can be extended a maximum of 160 feet (50 meters).

Hot-swappable electronic components allow powered electronics to be disconnected and even replaced without removing terminal wiring or disturbing the self-forming bus.

The *removable label holder* allows for customized point labels.

LEDs provide status indication and diagnostic information for the I/O module, as well as for each point on the module.

All TX-I/O modules are also:

- DIN rail mounted
- High density (point count to physical dimensions)
- Hardware addressed with address keys
- Separable into terminal base and plug-in I/O module electronics for:
  - Improved installation workflow, allowing field wiring to be terminated prior to installation of electronics.

– Optimum diagnostics - connected peripheral devices can be measured without affecting or being affected by the I/O module.
– Quick replacement of electronics for service.

Module Introduction

P1 Bus Interface Module (TXB1.P1)

The P1 Bus Interface Module (P1 BIM) provides P1 FLN communication and power for TX-I/O modules. It does not contain application or control for the TX-I/O modules.

Features

- Communication on the P1 FLN or MEC Expansion Bus
- Support for 80 TX-I/O points
- Support for 10 I/O modules
- 24 Vac input
- Generation of 24 Vdc at 600 mA to power TX-I/O modules and peripheral devices
- Transfer of 24 Vac at a maximum of 4A to power peripheral devices
- Plug-in screw terminals
- AC Fuse isolates the peripheral device supply in case of overload or short-circuit. The fuse can be accessed from an installed module.
- Separate LEDs for module operation, FLN communication activity, 24 Vdc present on the TX-I/O bus, and monitoring of the 24 Vac fuse

Digital Input Modules (TXM1.8D and TXM1.16D)

The TXM1.8D and TXM1.16D are dedicated to monitoring, respectively, 8 and 16 digital input points. They monitor status signals from normally open (NO) or normally closed (NC), latched voltage free/dry contacts. All 8 points on the TXM1.8D module as well as 8 of the 16 points on the TXM1.16D module may be used as pulse counters up to 10 Hz. Each input point has a green LED for status indication.

Digital Output Modules (TXM1.6R and TXM1.6R-M)

The Digital Output Modules provide six NO or NC (form C), maintained or pulsed, voltage free/dry contacts. The contacts are rated for a maximum of 250 Vac at 4A. Each I/O point has a green LED for status indication.

The TXM1.6R-M module is also equipped with manual override switches. An orange LED per override switch indicates override status individually per point.

Universal Modules (TXM1.8U and TXM1.8U-ML)

The TXM1.8U and TXM1.8U-ML are universal modules, allowing each of their 8 points to be individually software configured as digital input, analog input, or analog output to best meet the specific application needs.

Features

All Universal modules provide:

- AC supply voltage for peripheral devices such as valves and actuators
- Green LED status per I/O point that varies in intensity according to the voltage and current (directly proportional)

Digital input support includes:

- Voltage free/dry contacts
- Pulse counters up to 25 Hz

Analog input sensor support includes:

- 1k Nickel – Landis & Gyr curve
- 1k Platinum – 375 and 385 coefficient
- 10k and 100k Thermistor – Type II Curve

Active input and output support includes:

- Analog input voltage 0-10 Vdc
- Analog output voltage 0-10 Vdc

NOTE: Active inputs and outputs are permitted on the same module when connected sensors are powered from that module. When sensors are externally powered, active inputs and outputs should be on separate modules.

TXM1.8U-ML modules are also equipped with a local override/identification device (LOID), which includes an LCD signal display. The LCD displays the following information for each IO point:

- Configured signal type
- Symbolic display of process value
- Notification of faulty operation, short circuit, or sensor open circuit

Orange LEDs indicate override status individually per point.

Super Universal Modules (TXM1.8X and TXM1.8X-ML)

TXM1.8X and TXM1.8X-ML Super Universal modules share all of the Universal module features, and also provide:

- Analog input current 4-20 mA
- Analog output current 4-20 mA (four current outputs maximum per module on Points 5 through 8)
- 24 Vdc supply voltage for sensors at a maximum of 200 mA per module

NOTE: Active inputs and outputs are permitted on the same module when connected sensors are powered from that module. When sensors are externally powered, active inputs and outputs should be on separate modules.

TX-I/O Power Supply (TXS1.12F4)

Features

The TX-I/O Power Supply:

- Generates 24 Vdc at 1.2A to power TX-I/O modules and peripheral devices.
- An LED provides an indication of 24 Vdc on the TX-I/O bus.
- Up to 4 TX-I/O Power Supplies can be operated in parallel, with a maximum of two per DIN rail.
- Transfers 24 Vac at 4A to power TX-I/O modules and peripheral devices.
- Can be located within a row of TX-I/O modules or at the beginning of a new DIN rail.
- Routes CS (+24 Vdc Communication Supply) and CD (Communication Data signal) between DIN rails.
- Provides an input point for 24 Vac to power additional peripheral devices.
- Isolates the 24 Vac peripheral device supply in case of overload or short-circuit. The replaceable AC fuse can be accessed from an installed module.
- Indicates the AC fuse status (via LED) for easy diagnostics.

TX-I/O Bus Connection Module (TXS1.EF4)

Features

The Bus Connection Module:

- Transfers 24 Vac at 4A to power TX-I/O modules and peripheral devices.
- Can be located within a row of TX-I/O modules or at the beginning of a new DIN rail.
- Routes CS (+24 Vdc Communication Supply) and CD (Communication Data Signal) between DIN rails.
- Provides an input point for 24 Vac to power additional peripheral devices.
- Isolates the 24 Vac peripheral device supply in case of overload or short-circuit. The replaceable AC fuse can be accessed from an installed module.
- Indicates the AC fuse status (via LED) for easy diagnostics.

I/O Functions by Module

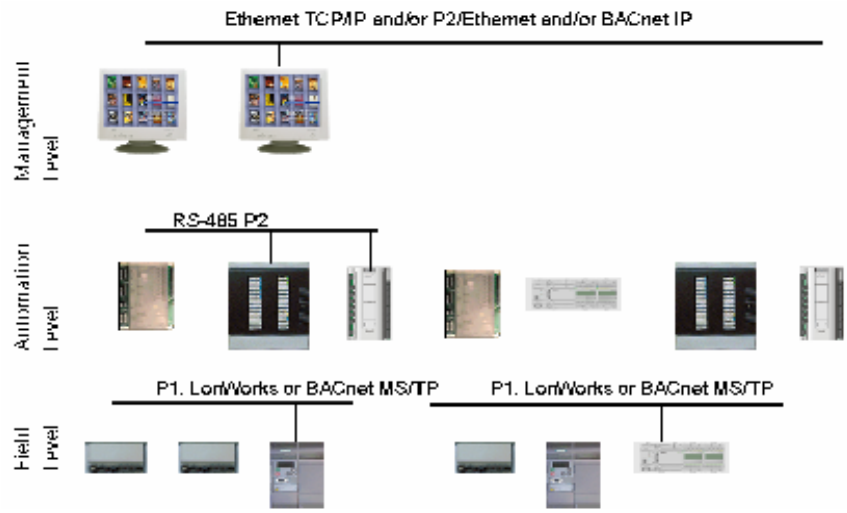
TX-I/O™ function	Description	Module type							
		TXM1.8D	TXM1.16D	TXM1.8U	TXM1.8U-ML	TXM1.8X	TXM1.8X-ML	TXM1.6R	TXM1.6R-M
		Maximum number of functions per module							
Digital inputs									
Binary Input	Status indication, voltage-free/dry contact	8	16	8	8	8	8		
Counter	Count/accumulator, voltage-free/dry pulse contact,	8	8	8	8	8	8		
Analog Inputs	Temperature LG-Ni1000			8	8	8	8		
	Temperature Pt 1000 375			8	8	8	8		
	Temperature Pt 1000 385			8	8	8	8		
	Temperature (NTC) 10 K			8	8	8	8		
	Temperature (NTC) 100 K			8	8	8	8		
	Voltage, DC 0 ... 10V *			8	8	8	8		
	Current DC 4... 20 mA *					8	8		
Digital outputs									
BO OnOff	Latched contact, AC/DC 250V, 4A							6	6
BO Pulse	Pulse							6	6
Analog Outputs	DC 0..10 V *			8	8	8	8		
	DC 4 ... 20 mA *					4	4		

* Active inputs and active outputs (0-10V and 4-20 mA) must be located on different modules if sensors are externally powered.

TX-I/O Network Architecture Examples

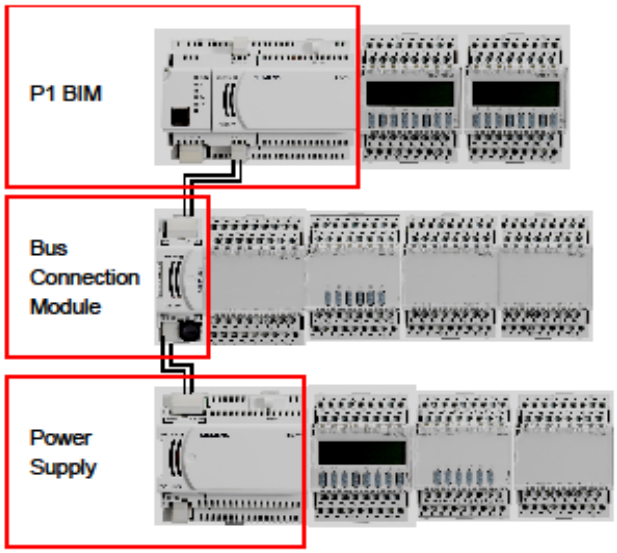
The following architecture picture shows TX-I/O modules connected to a P1 BIM located on:

- the Field Level Network
- the MEC Expansion Bus



TX-I/O Bus Extension

The following picture shows the TX-I/O bus extended using a Bus Connection Module and TX-I/O Power Supply. The TX-I/O bus can be a maximum of 160 feet (50 meters) and may extend outside an enclosure.



Technical Specifications:

Voltage requirements	24 Vac +/- 20% @ 50/60 Hz
Power Consumption	
Power Supply	20 VA
P1 BIM	35 VA

With the above power consumption, the Power Supply produces 1.2A 24VDC (28.8 W) and the BIM provides 0.6A 24VDC (14.4 W) to be used by the following:

TXM1.8D	1.1 W
TXM1.16D	1.4 W
TXM1.8U	1.5 W
TXM1.8U-ML	1.8 W
TXM1.8X	2.2 W
TXM1.8X-ML	2.3 W
TXM1.6R	1.7 W
TXM1.6R-M	1.9 W

Terminations	
I/O Terminals	20-12 AWG Solid
	20-14 AWG Stranded
BIM and Power Supply	2 or 3 position screw terminal pluggable blocks
Operating Environment	+32°F to +122°F (0°C to 50°C)
	5 to 95% rh (non-condensing)
Agency Listings	UL 864 UUKL
	ULC-C100 UUKL7
	UL 916 PAZX
	CSA 22.2 No. 205 PAZX7
Agency Compliance	FCC Compliance
	Australian EMC Framework (C-Tick)
	European EMC Directive (CE)
	European Low Voltage Directive (CE)
Dimensions	
TX-I/O Modules:	2.52" (64 mm) L × 3.54" (90 mm) W × 2.75" (70 mm) D
TX-I/O BIM, P1	5" (128 mm) L × 3.54" (90 mm) W × 2.75" (70 mm) D
TX-I/O Power Supply	3.78" (96 mm) L × 3.54" (90 mm) W × 2.75" (70 mm) D
TX-I/O Bus Connection Module:	1.26" (32 mm) L × 3.54" (90 mm) W × 2.75" (70 mm) D

TX-I/O Ordering Information

Description	Product Number
TX-I/O Module, 8 DI points	TXM1.8D
TX-I/O Module, 16 DI points	TXM1.16D
TX-I/O Module, 8 Universal points	TXM1.8U
TX-I/O Module, 8 Universal points with LOID	TXM1.8U-ML
TX-I/O Module, 8 Super Universal points	TXM1.8X
TX-I/O Module, 8 Super Universal points with LOID	TXM1.8X-ML
TX-I/O Module, 6 DO with Relay points	TXM1.6R
TX-I/O Module, 6 DO with Relay points with manual override	TXM1.6R-M
TX-I/O Power Supply, 1.2 A, 4A Fuse	TXS1.12F4
TX-I/O Bus Connection Module, 4A Fuse	TXS1.EF4
TX-I/O Bus Interface Module, P1	TXB1.P1
2 sets, Address Keys 1-12	TXA1.K12
Address Keys 1-24	TXA1.K24
Address Keys 25-48	TXA1.K-48
Address Keys 49-72	TXA1.K-72
Labels for TX-I/O 100 sheets/pack Letter format	TXA1.LLT-P100
Replacement Label Holders	TXA1.LH

Regions where this Product is Sold

(US, Asia Pacific, Canada, Latin America, UK)

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SIEMENS
Z

Fire Safety

Strobes, Horns, Horn/Strobes

ENGINEER AND ARCHITECT SPECIFICATIONS

- UL listed. ULC, CSFM, and FM pending.
- ADA/NFPA compliant
- EZ Mount design, with separate base plate, provides ability to pre-wire the base and test the circuit wiring before the walls are covered
- The base plate is protected by a disposable cover and the appliances can quickly snap onto the base after the walls are painted.
- EZ Mount Universal Mounting Plate (ZBB) – uses single plate for ceiling and wall mount installations
- Wall Mount models feature field selectable candela settings of 15/30/75/110cd and 135/185cd
- Ceiling Mount models feature field selectable candela settings of 15/30/75/95cd and 115/177cd
- Strobes can be synchronized using the Siemens DSC sync modules, FS-250 panel, XLS panel, or PAD-3 power supply with built-in sync protocol
- "Special Applications" listed with Siemens panels
- Strobes produce 1 flash per second
- Selectable Continuous Horn or Temporal (Code-3) Tones with selectable 90 or 95 dBA setting (ZH model)

Series ZH

Series ZR

ZR AND ZH Mounting

Description

The Siemens Series Z notification appliances feature an easy snap on base that is designed to simplify the installation and testing of horns, strobes, and horn/strobes. The separate Series Z snap on base can be pre-wired so circuit wiring can be fully tested before the appliance is installed and before the walls are covered. Once all surrounding work is complete, the appliance can be simply installed by snapping it on the base. Shorting contacts in the base, which provide continuity for circuit testing, are permanently opened when the appliance is installed so any subsequent removal of the appliance will indicate a trouble condition on that circuit at the control panel when circuit supervision is enabled. The same base is used for all Series Z horns, strobes and horn/strobes to provide consistent installation and easy replacement of appliances if required. A locking screw is also included for the appliance to provide extra secure installation.

The Siemens Series Z appliances incorporate the same dependable circuitry and high efficiency optics that are used in Siemens ST strobes, NS horn/strobes and NH horns and have the same high performance ratings. The Series Z appliances are "Special Applications" listed with Siemens panels.

Engineering Specifications

General

Audible/visual notification appliances shall be listed for indoor use and shall meet the requirements of FCC Part 15 Class B. These appliances shall be listed under UL Standard 1971, (Standard for Safety Signaling Devices for Hearing Impaired) and UL Standard 464 (Fire Protective Signaling). The appliances shall use a universal backplate that shall allow mounting to a single-gang, double-gang, 4-inch square, 4" octal, or a 3-1/2" octal backbox. Two wire appliance wiring shall be capable of directly connecting to the mounting back plate. Continuity checking of the entire NAC circuit prior to attaching any audible/visual notification appliances shall be allowed. A dust cover shall fit and protect the mounting plate. The dust cover shall be easily removed when the appliance is installed over the backplate. Removal of an appliance shall result in a trouble condition by the Fire Alarm Control Panel (FACP).

Strobes

Strobe appliances shall produce a minimum flash rate of 60 flashes per minute (1 flash per second) over the Regulated Input Voltage Range and shall incorporate a

CATALOG SHEET 2584

Xenon flashtube enclosed in a rugged Lexan® lens. The strobes shall be available with two or four field selectable settings in one unit and shall be rated, per UL 1971, for up to 185 cd for wall mounting and 177 cd for ceiling mounting. The strobes shall operate over an extended temperature range of 32°F to 120°F (0°C to 49°C) and be listed for maximum humidity of 95% RH. Strobe inputs shall be polarized for compatibility with standard reverse polarity supervision of circuit wiring by a Fire Alarm Control Panel (FACP).

Audibles and Audible/Strobe Combinations

Horns and horn/strobes shall be listed for Indoor use under UL Standard 464. The horns shall be able to produce a continuous output or a temporal code-3 output that can be synchronized. The horns shall have at least 2 sound level settings of 90 and 95 dBA.

Synchronization Modules

When synchronization of strobes or temporal Code-3 audibles is required, the appliances shall be synchronized using the Siemens DSC sync modules, FS-250 panels, XLS panels, or PAD-3 power suppies with built-in sync protocol. The strobes shall not drift out of synchronization at any time during operation. Audibles and strobes shall be able to be synchronized on a 2-wire circuit with the capability to silence the audible if required. If the sync module or power supply fails to operate (i.e., contacts remain closed), the strobes shall revert to a non-synchronized flash rate. All notification appliances shall be listed for "Special Applications".

- Strobes are designed to flash at 1 flash per second minimum over their "Regulated Input Voltage Range".
- All candela ratings represent minimum effective strobe intensity based on UL Standard 1971.
- Series ZH Strobe products are listed under UL Standards 1971 and 464 for indoor use with a temperature range of 32°F to 120°F (0°C to 49°C) and maximum humidity of 93% (± 2%).
- Series ZH horns are listed under UL Standard 464 for audible signal appliances (Indoor use only).

Technical Information

For complete technical information, please consult the relevant installation sheets as well as the Siemens Compatibility Guide.

Ordering Information / Mounting Requirements / Approvals

Model Number	Order Code	Mounting Options#	Agency Approvals			
			UL	ULC	CSFM	FM
ZH-MC-R	500-636161	B, D, E, F	X	#	#	#
ZH-MC-W	500-636162	B, D, E, F	X	#	#	#
ZH-HMC-R	500-636163	B, D, E, F	X	#	#	#
ZH-HMC-W	500-636164	B, D, E, F	X	#	#	#
ZH-R	500-636159	B, D, E, F	X	#	#	#
ZH-W	500-636160	B, D, E, F	X	#	#	#
ZH-MC-CR	500-636165	B, D, E, F	X	#	#	#
ZH-MC-CW	500-636166	B, D, E, F	X	#	#	#
ZH-HMC-CR	500-636167	B, D, E, F	X	#	#	#
ZH-HMC-CW	500-636168	B, D, E, F	X	#	#	#
ZR-MC-R	500-636169	B, D, E, F	X	#	#	#
ZR-MC-W	500-636170	B, D, E, F	X	#	#	#
ZR-HMC-R	500-636171	B, D, E, F	X	#	#	#
ZR-HMC-W	500-636172	B, D, E, F	X	#	#	#
ZR-MC-CW	500-636174	B, D, E, F	X	#	#	#
ZR-MC-CR	500-636173	B, D, E, F	X	#	#	#
ZR-HMC-CR	500-636175	B, D, E, F	X	#	#	#
ZRS-HMC-CW	500-636176	B, D, E, F	X	#	#	#
ZBB-R	500-636193	Accessory - Includes base, dust cover, mounting screws and installation sheet				
ZBB-W	500-636194	Accessory - Includes base, dust cover, mounting screws and installation sheet				

X = listed/approved # = pending * = Refer to Data Sheet #2585 for mounting options.

WARNING: PLEASE READ THESE SPECIFICATIONS AND INSTALLATION INSTRUCTIONS CAREFULLY BEFORE USING, SPECIFYING OR APPLYING THIS PRODUCT. FAILURE TO COMPLY WITH ANY OF THESE INSTRUCTIONS, CAUTIONS AND WARNINGS COULD RESULT IN IMPROPER APPLICATION, INSTALLATION AND/OR OPERATION OF THESE PRODUCTS IN AN EMERGENCY SITUATION, WHICH COULD RESULT IN PROPERTY DAMAGE, AND SERIOUS INJURY OR DEATH TO YOU AND/OR OTHERS.

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July 2007
New Issue

SIEMENS

Technical Specification Sheet
Document No. 149-914
December 17, 2009

Standard Room Temperature Sensors (0 to 10V, 4 to 20 mA)

Figure 1. Standard Room Temperature Sensor.

Description

The Standard Room Temperature Sensors monitor and transmit changes in room temperature to the building control system. This family of products offers a number of features. The wide assortment offers the specific product that is compatible with your specific building automation system. The product family includes plain sensing-only models as well as full-featured models with digital display and up/down buttons for setpoint adjustment. All sensors incorporate precision temperature sensing elements to accurately and reliably measure room temperature. A styled ventilation ring optimizes airflow through the cover for good measurement response and superior control.

Features

- Digital display: The temperature display provides an easy-to-read room temperature value in degrees Fahrenheit or Celsius. Temperature engineering units are toggled between Degrees C and F on the display by pressing both the up and down arrow buttons for three seconds.
- Up/down buttons for setpoint adjustment: The basic setpoint adjustment incorporates up and down buttons to increase or decrease the setpoint. An access door aesthetically conceals the up/down buttons.
- Occupancy override button: The flush-mounted override button allows an occupant to change to an occupied control schedule during the unoccupied cycle. The access door aesthetically conceals the occupancy override button.
- Maintenance-free: These sensors draw a small amount of power directly from the controller power supply or from a local ac or dc transformer. They do not use batteries, which eliminates the need for servicing battery (replacement and disposal).

Specifications

Setpoint Temperature Range	63°F to 83°F (°C, if applicable)
Operating Temperature Range	55°F to 95°F (13°C to 35°C)
Output Temperature signal	0 to 10 Vdc or 4 to 20 mA
Line Output Signal for Setpoint Adjustment Output	0 to 10 Vdc for 63°F to 83°F or 18°C to 26°C 4 to 20 mA for 63°F to 83°F or 18°C to 26°C
Sensing Element Accuracy	±0.9°F (±0.5°C) over the operating range
Sensor Accuracy	±1.8°F (±1.0°C) over the operating range
Installation:	300 ft (91m) to 750 ft (228m) maximum cable length 18 to 22 AWG, twisted pair, NEC Class 2
Calibration Adjustments	None required
Cover Dimensions	Height: 3-11/32 in. (85 mm) Width: 2-1/2 in. (63 mm) Depth: 1-1/2 in. (38 mm)
Cover Color	White
Voltage Supply	24 Vdc
Display Options	Up/down setpoint adjustment buttons
Sensing Element Type	Digital sensor integrated circuit

Accessories Ordering Information

Description	Product Part Number
Occupancy Override Button, 25-pack (White)	544-480B
Setpoint Door, 25-pack (White)	544-481B
Blank Bezel, 25-pack (White)	544-482B
Room Temperature Sensor Repair Kit, Single-pack (White)	544-483B
Blanking Override Button, 25-pack (White)	544-484B
Single Adapter Base Mounting Kit	544-782B
Double Adapter Base Mounting Kit	544-783B
Non-Conduit Rough-In Kit, Double	544-784
Extender Ring Kit	544-785B

Product Ordering Information

Product Number	Description
QAA2062.FWNU	Room Temperature Sensor, 0 to 10 Volt, 55 to 95°F, Sensing, Display, Setpoint, Override, White, No Logo
QAA2062.FWU	Room Temperature Sensor, 0 to 10 Volt, 55 to 95°F, Sensing, Display, Setpoint, Override, White, Siemens Logo
QAA2062.WNU	Room Temperature Sensor, 0 to 10 Volt, 55 to 95°F, Sensing Only, White, No Logo
QAA2062.WU	Room Temperature Sensor, 0 to 10 Volt, 55 to 95°F, Sensing Only, White, Siemens Logo
QAA2072.FWNU	Room Temperature Sensor, 4 to 20 mA, 55 to 95°F, Sensing, Display, Setpoint, Override, White, No Logo
QAA2072.FWU	Room Temperature Sensor, 4 to 20 mA, 55 to 95°F, Sensing, Display, Setpoint, Override, White, Siemens Logo
QAA2072.WNU	Room Temperature Sensor, 4 to 20 mA, 55 to 95°F, Sensing Only, White, No Logo
QAA2072.WU	Room Temperature Sensor, 4 to 20 mA, 55 to 95°F, Sensing Only, White, Siemens Logo

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Document No. 149-914
Printed in the U.S.A.

SIEMENS

Installation Instructions
Document No. 129-439
March 18, 2011

Q-Series Room Temperature Sensors 0 to 10V or 4 to 20 mA

Product Description

The Q-Series Room Temperature Sensors monitor and transmit changes in temperature to building control systems. Several models are available.

Product Numbers

QAA2062.FWNU	QAA2072.FWNU
QAA2062.FWU	QAA2072.FWU
QAA2062.WNU	QAA2072.WNU
QAA2062.WU	QAA2072.WU

Caution Notations

CAUTION:	⚠	Equipment damage or loss of data may occur if you do not follow the procedures as specified.

Required Tools

- Phillips screwdrivers, sizes 1 and 2
- Medium flat-blade screwdriver
- Wire cutters/strippers
- Tape measure
- Medium-duty electric drill
- Drill bit for wall anchor hole
- Marker or pencil
- Two No. 10 screws and wall anchors

Expected Installation Time

30 minutes

Prerequisites

- Ensure that the appropriate field wiring is installed.

  Appropriate wiring is one or more twisted pair or three conductor cables (plenum or non-plenum as required) within the maximum wiring run length for the temperature controller. The maximum recommended length is 750 feet (229 m).
- Ensure that all wiring complies with National Electric Code (NEC) and local regulations.

Installation

Always mount the sensor vertically.

Locate the sensor:

- According to design specifications and local regulations.
- Where the air circulates around it freely (not in recessed areas or behind doors).
- Allowing a minimum of 4 inches (10 cm) of free space above and below for proper airflow and access.
- Away from drafts caused by doors, windows, outside walls, air registers, pipes, return air plenums, etc.
- Away from heat sources, such as strong lights, fireplaces, direct sunlight, etc.
- On an inside wall (preferably), about 5 feet (1.5 m) above the finished floor.

  NOTE: Local codes (such as the Americans with Disabilities Act) may require a specific mounting height.

Drywall Mounting (No Rough-in), Typical

1. Using the sensor base plate as a template, mark the center field wiring hole and the mounting hole locations (Figure 1).

   NOTE: For drywall mounting, use only the top and bottom holes.
2. Drill two 3/16-inch (4.8 mm) mounting holes. If you are using screws to attach the sensor, insert two plastic wall anchors into the holes.
3. Cut a 1-inch (25 mm) center hole with a hole saw.

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Installation Instructions
March 18, 2011

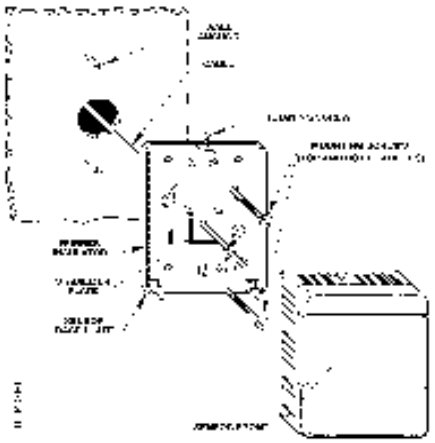

Figure 1. Drywall Mounting (No Rough-in), Typical.

4. Pull about 6 inches (150 mm) of the field wiring cable through the hole in the wall and the sensor base plate.
5. Secure the field wiring in the terminal block located on the printed circuit board.
6. Push the field wiring cable through the hole in the wall and loosely mount the sensor base plate on the wall using the screws provided. Do not tighten the screws.
7. Level the sensor base plate for appearance and then tighten the mounting screws.

CAUTION:

Over-tightening the mounting screws may cause the sensor base plate to flex or crack.

8. Feed the extra field wiring back through the hole in the sensor base plate.
9. Snap the sensor pieces together by hooking the feet of the base plate into the slots on the front plate, then pushing the top of the sensor until it snaps into place.
10. Tighten the sensor front retaining screw (Figure 1).

The installation is now complete.

Wiring Diagrams

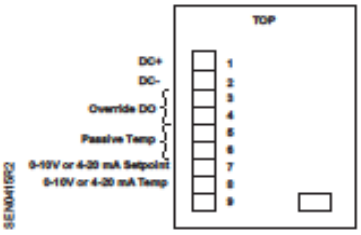

Table 1. Room Temperature Sensors with Active Outputs Installation, 0V to 10V or 4 to 20mA.

Available Features	Sensor Terminals Used			
	Power* 1 & 2	Temp 8 & 2	Setpt 7 & 2	Ovrd 3 & 4
Temp: Sensing only	•	•	–	–
Temp: Sensing with Display	•	•	–	–
Temp: Full-featured	•	•	•	•

* Power input to devices is 19 to 35 Vdc.

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Document No. 129-439
Printed in the USA
Page 2 of 2

SIEMENS

Technical Specification Sheet
Document No. 149-992
February 5, 2009

Q-Series Outdoor Air or Critical Environment Relative Humidity and Relative Humidity & Temperature Sensors

Figure 1. Q-Series Relative Humidity and Relative Humidity & Temperature Sensor with Outdoor Air Sun Shield.

Figure 2. Q-Series Relative Humidity and Relative Humidity & Temperature Critical Environment Room Sensor.

Figure 3. Q-Series Relative Humidity Removable Sensing Tip.

Figure 3. Q-Series Relative Humidity and Relative Humidity & Temperature Critical Environment Room Sensor with Display.

Description

The Q-Series Outdoor Air Relative Humidity and Relative Humidity & Temperature Sensors monitor and transmit changes in humidity and temperature to the building control systems. These units are especially suited for applications where precise, stable humidity sensing is required. Standard models available are 2% and 2% certified, for both humidity only and combination humidity with temperature sensing. Sensors are offered with either 4 to 20 mA or 0 to 10 Volt output signals. Some models are available with display.

All versions are also equipped with a removable, replaceable sensing tip. The removable sensing tips have a threaded connection that allows the user to screw off the tip without disrupting the installation or wiring. Siemens sensors with replaceable tips are ideal for applications where measurement accuracy is critical and sensor replacement is not an option. Replaceable sensing tips eliminate the need for accuracy adjustment.

All certified sensors include a certificate of calibration. The certification is based on a 3-point humidity and 3-point temperature verification and calibration of the sensing element.

Sun shields are sold separately.

Specifications – Humidity Element

Measurement range	0 to 100% rh
Accuracy at room temperature (73°F, 20°C)	±2% rh, 0-95% rh
Temperature effect	Less than 0.1% per degree C
Sensing element	Capacitive humidity sensing element
Output signal - rh only units	4 to 20 mA or 0 to 10 Vdc, 0 to100% linear, proportional
Output signal - rh/T units	4 to 20 mA or 0 to 10 Vdc, 0 to100% linear, proportional
Polarity protection	Yes

Specifications–Temperature Element (for combination RH/T units only)

Time constant at 0°C to 50°C and 10-80%rh	Approx. 20 seconds in moving air
Accuracy:	± 1.4°F: 59°F to 95°F (± 0.8°C): (15°C to 35°C) ± 1.8°F: -40°F to 59°F and 95°F to 158°F (± 1.0°C): (-40°C to 15°C and 35°C to 60°C)
Output signal	4 to 20 mA or 0 to 10 Vdc, 0 to 100% linear, proportional, (terminal U2)
Calibration adjustments	None

General Specifications

Operating conditions	
Relative humidity	0 to 100%
Temperature (jumper selectable)	32°F to 122°F (0°C to 50°C) **or** -31°F to 95°F (-35°C to +35°C) **or** -40°F to 158°F (-40°C to 70°C)
Installation	18 AWG cable length shared in conduit with other sensor wiring 750 ft (229 m) max.
Connections	Screw terminals
Dimensions	Outdoor Air Probe: .6" OD × 3.3" L (15 mm × 84 mm) Outdoor Air Housing: 3.1" L × 2.3" W × 1.5" D (80 mm × 60 mm × 40 mm) Shield (mounted): 3.43" H × 3.5" W × 4.1" D (87 mm × 89 mm × 104 mm)
Voltage requirement	
0 to 10 Vdc output types	13.5 to 35 Vdc or 24 Vac ± 20%
4 to 20 mA output types	13.5 to 35 Vdc
Power consumption	<1 VA
Material Type	Polycarbonate plastic
CE and UL listed	UL 873 standard for Temperature Indicating and Regulating Equipment

Ordering Information

Part Number	Description
QFA3100	Outdoor air humidity sensor (2%), 0 to 10 Vdc
QFA3101	Outdoor air humidity sensor (2%), 4 to 20 mA
QFA3160	Outdoor air humidity sensor (2%), 0 to 10 Vdc/Temp 0 to 10 Vdc
QFA3171	Outdoor air humidity sensor (2%), 4 to 20 mA Temp 4 to 20 mA
QFA4171	Outdoor air humidity sensor (2%), 4 to 20 mA/Temp 4 to 20 mA (certified version)
QFA4160	Outdoor air humidity sensor (2%), 0 to 10 Vdc/Temp 0 to 10 Vdc (certified version)
QFA3160D	Outdoor air humidity sensor (2%), 0 to 10 Vdc/Temp 0 to 10 Vdc with display
QFA3171	Outdoor air humidity sensor (2%), 4 to 20 mA Temp 4 to 20 mA
QFA3171D	Outdoor air humidity sensor (2%), 4 to 20 mA Temp 4 to 20 mA with display
QFA4171	Outdoor air humidity sensor (2%), 4 to 20 mA/Temp 4 to 20 mA (certified version)
QFA4171D	Outdoor air humidity sensor (2%), 4 to 20 mA/Temp 4 to 20 mA (certified version) with display
QFA4160	Outdoor air humidity sensor (2%), 0 to 10 Vdc/Temp 0 to 10 Vdc (certified version)
QFA4160D	Outdoor air humidity sensor (2%), 0 to 10 Vdc/Temp 0 to 10 Vdc (certified version) with display
Accessories	
AQF3101	Sensor filter cap
AQF4150	Replaceable certified sensor tip
AQF3100	Sun Shield (must be ordered separately)
74 662 0104 0	US 1/2-in rigid conduit adapter

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Installation Instructions
Document No. 129-416
October 5, 2009

Q-Series Outdoor Air Relative Humidity and Relative Humidity & Temperature Sensors

Product Description

The Q-Series Outdoor Air Relative Humidity, and Relative Humidity & Temperature Sensors monitor and transmit changes in humidity and temperature to the building control systems. These units are especially suited for applications where precise, stable humidity sensing is required. Standard models available are 2% and 2% certified, for both humidity only and combination humidity with temperature sensing. Sensors are offered with either 4 to 20 mA or 0 to 10 Volt output signals.

Product Numbers

Part Number	Description
QFA3100	Outdoor air humidity sensor (2%), 0 to 10 Vdc
QFA3101	Outdoor air humidity sensor (2%), 4 to 20 mA
QFA3160	Outdoor air humidity sensor (2%), 0 to 10 Vdc/Temp 0 to 10 Vdc
QFA3160D	Outdoor air humidity sensor (2%), 0 to 10 Vdc/Temp 0 to 10 Vdc with display
QFA3171	Outdoor air humidity sensor (2%), 4 to 20 mA/Temp 4 to 20 mA
QFA3171D	Outdoor air humidity sensor (2%), 4 to 20 mA/Temp 4 to 20 mA with display
QFA4171	Outdoor air humidity sensor (2%), 4 to 20 mA/Temp 4 to 20 mA, certified
QFA4171D	Outdoor air humidity sensor (2%), 4 to 20 mA/Temp 4 to 20 mA, certified with display
QFA4160	Outdoor air humidity sensor (2%), 0 t 10 Vdc/Temp 0 to 10 Vdc, certified
QFA4160D	Outdoor air humidity sensor (2%), 0 t 10 Vdc/Temp 0 to 10 Vdc, certified with display
Accessories	
AQF3101	Sensor filter cap
AQF4150	Replaceable, certified sensor tip
AQF3100	Sun shield
74 662 0104 0	US 1/2-inch rigid conduit adapter

Required Tools

- Phillips screwdrivers, sizes No. 1 and No. 2
- Medium flat-blade screwdriver
- Wire cutters/strippers
- Tape measure
- Medium-duty electric drill
- Drill bit for wall anchor hole
- Marker or pencil
- Two No. 10 screws and wall anchors

Expected Installation Time

30 minutes

Prerequisites

- Ensure that the appropriate field wiring is installed.

  Appropriate wiring is one or more twisted pair or three conductor cables (plenum or non-plenum as required) within the maximum wiring run length for the humidity/temperature controller. The maximum recommended length is 750 feet (229 m).
- Ensure that all wiring complies with National Electric Code (NEC) and local regulations.

Installation

1. Determine where the sensor is to be located and install the Sun Shield, AQF3100, as shown in Figure 1. The installation surface determines which mounting components are to be used.

   NOTE: The shield must be mounted vertically as shown in Figure 1.
2. Remove sensor cover and install plug in knockout next to sensing probe. See Figure 1 (2).
3. Pull the field wiring through the conduit and into the sensor base. See Figure 2.

Document No. 129-416
Installation Instructions
October 5, 2009

4. Connect the field wiring to the sensor terminal block on the base. See Figures 3 and 4 for wiring diagrams.

5. Install the sensor onto the Shield as shown. See Figure 1 (7).

The installation is now complete.

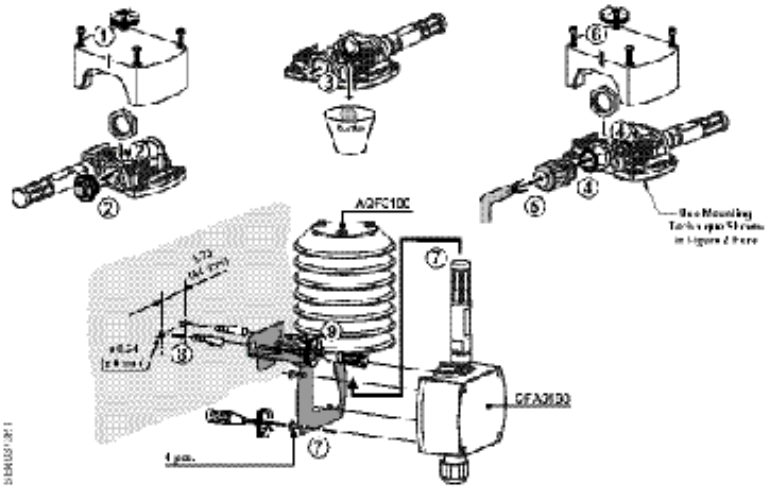

Figure 1. Rh/T Outdoor Air Sensor Installation.

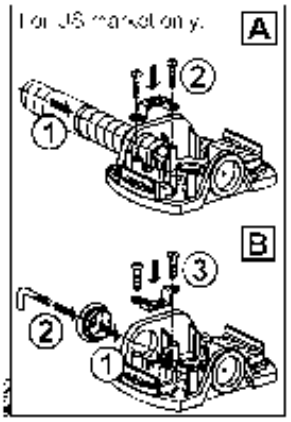

Figure 2. Field Wiring.

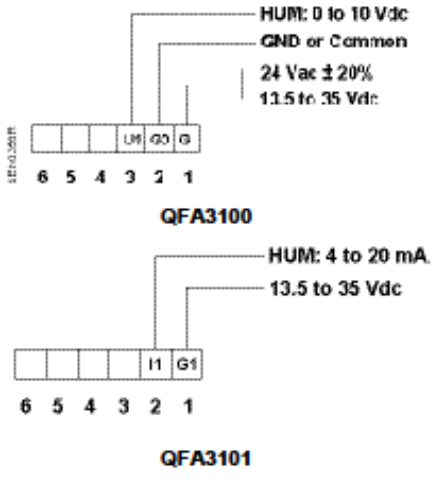

Figure 3. Wiring Diagrams for RH Sensors.

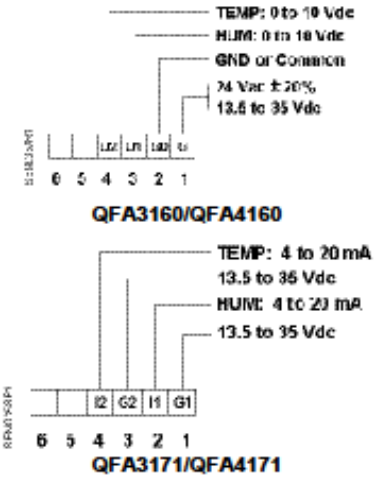
TEMP: 0 to 10 Vdc
HUM: 0 to 10 Vdc
GND or Common
24 Vac ± 20%
13.5 to 35 Vdc
6 5 4 3 2 1
QFA3160/QFA4160
TEMP: 4 to 20 mA
13.5 to 35 Vdc
HUM: 4 to 20 mA
13.5 to 35 Vdc
I2 G2 I1 G1
6 5 4 3 2 1
QFA3171/QFA4171

Figure 4. Wiring Diagrams for RH/T Sensors.

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SIEMENS

Technical Specification Sheet
Document No. 149-910
November 17, 2006

QPA20… Series Room Air Quality Sensors

Description

The QPA20… series room air quality sensors optimize room comfort by enabling demand-controlled ventilation. The sensors can acquire: CO_2 and volatile organic compound (VOC) concentrations, relative humidity, and temperature. Models are available for CO_2, CO_2/VOC, CO_2/T, and CO_2/T/RH.

The sensor evaluates the CO_2/VOC concentrations and transforms it to a 0 to 10 Vdc linear proportional output signal.

For models with humidity, a capacitive humidity sensing element changes capacitance as a function of the relative humidity. An electronic measuring circuit converts the humidity signal to a continuous 0 to 10 Vdc signal that corresponds to a relative humidity range of 0 to 100%. For models with temperature, the sensor acquires room temperature with a sensing element that changes electrical resistance as a function of the temperature. The resistance is converted to an active 0 to 10 Vdc output signal that corresponds to a temperature range of 32 to 122°F (0 to 50°C) or -31 to 95°F (–35 to 35°C).

Sensors with an LCD window display the following measured values:

- CO_2 in ppm
- CO_2 and VOC as a bar chart (4 bars ≈ 2V, 20 bars ≈ 10V)
- Temperature in °C or °F
- Relative humidity in %

The wall-mounted sensors are suited for use with all systems and devices capable of acquiring and handling a 0 to 10 Vdc output signal.

Features

- Multisensor for CO_2/VOC, temperature, and humidity-temperature
- Maintenance-free infrared CO_2sensing element, VOC sensing element based on a heated tin dioxide semiconductor
- 24 Vac or 13.5 to 35 Vdc operating voltage, 0 to 10 Vdc output signals

QPA20... Series Room Air Quality Sensor.

QPA20... Series Room Air Quality Sensor with Display.

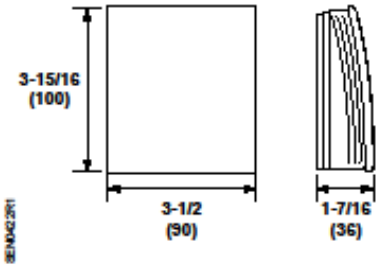
General Specifications

Power Supply:
- Operating voltage (SELV): 24 Vac ±20% or 13.5 to 35 Vdc
- Frequency: 50/60 Hz
- Power consumption: ≤2 VA

Electrical:
- Screw terminals: 2 × 16 AWG or 1 × 14 AWG

Environmental:
- Temperature
  - Operating: 23 to 113°F (-5 to 45°C)
  - Storage: -13 to 158°F (-25 to 70°C)
- Humidity:
  - Operating: 0 to 95% rh (noncondensing)
  - Storage: <95% rh

Physical:
- Mounting: In 2 × 4 inch (5 × 10 cm) electrical conduit box
- Weight in lb (kg):
  - Without display: 0.22 lb (0.10 kg)
  - With display: 0.26 lb (0.12 kg)



Dimensions in inches (mm).

Product Numbers and Specifications

Specification \ Product Number	QPA2000	QPA2002	QPA2002D	QPA2060	QPA2060D	QPA2062	QPA2062D
CO_2 measuring range: 0 to 2000 ppm Accuracy: ≤±50 ppm +2% of measured value Output signal: 0 to 10 Vdc, linear Recalibration free: 8 years	•	•	•	•	•	•	•
VOC sensitivity: Low (R1), Normal (R2), High (R3)		•	•				
Temperature measuring range (slope and intercept): R2 and R3: 32 to 122°F (0 to 50°C) R1: -31 to 95°F (-35 to 35°C) Temperature measuring element: QPA2060: PT1000 QPA2062: NTC 10 kΩ Measuring accuracy in the range of: -31 to 59°F (-35 to 15°C): ±1K 59 to 95°F (15 to 35°C): ±0.8K 95 to 122°F (35 to 50°C): ±1K				•	•	•	•
Humidity range of use: 0 to 95% rh (noncondensing) Humidity measuring range: (slope and intercept) 0 to 100% rh Measuring accuracy at 73°F (23°C), 24 Vac: 0 to 30% rh: ±5% rh 30 to 70% rh: ±3% rh 70 to 95% rh: ±5% rh						•	•
Display (LCD) of measured value			•		•		•

Ordering Information

UNIVERSAL SENSOR PROGRAM		**QPA2 0 x x . x**
TYPE	SENSOR	Q
MEASURING FAMILY	CO2/VOC	P
APPLICATION/LOCATION	ROOM	A
SENSOR TYPE	CO2	2
HOUSING TYPE	CO2 HOUSING	0
TEMPERATURE OUTPUT SIGNAL	NONE	0
	0 TO 10 VOLT	6
RH SIGNAL PRESENT		
CO2 OR VOC ONLY:	0 TO 10 VOLT	0
CO2/VOC AND RH:	0 TO 10 VOLT	2
SEPARATOR		.
FEATURE DESCRIPTION - ROOM TYPES		
	WITHOUT DISPLAY	<BLANK>
	WITH LCD DISPLAY	D

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Document No. 149-910
Country of Origin: US

SIEMENS

Installation Instructions
Document No. 129-435
August 25, 2011

QPA... Series Indoor Air Quality Room Sensors

Product Description

The QPA... Series Indoor Air Quality Room Sensors are especially suited for applications where precise, stable sensing of carbon dioxide (CO_2), temperature, or relative humidity is required. Some models sense volatile organic compounds (VOCs).

Product Numbers

Product Number	Description
QPA1000	VOC sensing only
QPA2000	CO_2 sensing only
QPA2002	CO_2 and VOC sensing only
QPA2002D	CO_2 and VOC sensing with display
QPA2060	CO_2 and temperature sensing (active) only
QPA2060D	CO_2 and temperature (active) sensing with display
QPA2062	CO_2, temperature (active) and rh sensing only
QPA2062D	CO_2, temperature (active) and rh sensing with display
QPA2080	CO_2 and temperature (passive) (depending on connected sensing element *)
QPA2080D	CO_2 and temperature (passive) (depending on connected sensing element *) with display

NOTE: QPA1000, QPA2000, QPA2002, and QPA2060 are available as no-logo variants. To order, add an "N"suffix (for example: QPA1000N).

* LG-Ni1000, Pt1000, Pt100, or NTC 10K ohm.

Additional Reference Documents

Technical Instructions	CE1N1961
Technical Specification Sheet	149-910

Expected Installation Time

30 minutes

Required Tools

- Phillips screwdrivers, sizes 1 and 2
- Small and medium flat-blade screwdriver
- Wire cutters/strippers
- Tape measure
- Medium-duty electric drill
- Drill bit for wall anchor hole
- Marker or pencil
- Two No. 10 screws and wall anchors

Prerequisites

- Ensure that the appropriate field wiring is installed.

  Appropriate wiring is one or more twisted pair or three conductor cables (plenum or non-plenum as required) within the maximum wiring run length for the humidity/temperature controller. The maximum recommended length is 750 feet (229 m).
- Ensure that all wiring complies with National Electric Code (NEC) and local regulations.

Installation

Always mount the sensor vertically.

Locate the sensor:

- According to design specifications and local regulations.
- Where the air circulates around it freely (not in recessed areas or behind doors).
- Allowing a minimum of 4 inches (10 cm) of free space above and below for proper airflow and access.
- Away from drafts caused by doors, windows, outside walls, air registers, pipes, return air plenums, etc.
- Away from heat sources, such as strong lights, fireplaces, direct sunlight, etc.
- On an inside wall (preferably), about 5 feet (1.5 m) above the finished floor.

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Installation, Continued

NOTES: Local codes (such as the Americans with Disabilities Act) may require a specific mounting height.

The end of the conduit at the sensor must be sealed to prevent inaccurate measurements due to drafts through the conduit.

Drywall Mounting (No Rough-in), Typical

1. Place a small screwdriver into the top of the sensor and press in the locking tab to remove the cover.

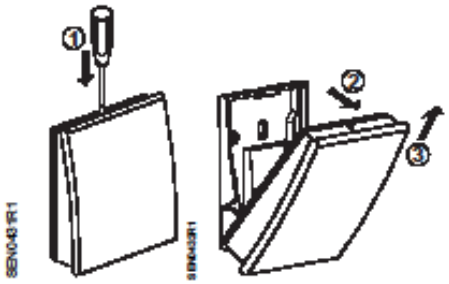

Figure 1.

2. Using the base as a template, mark the hole locations with a pencil.
3. Drill two 1/4-inch diameter holes for plastic wall anchors.
4. Using a mallet, tap in the plastic wall anchors flush with wall.

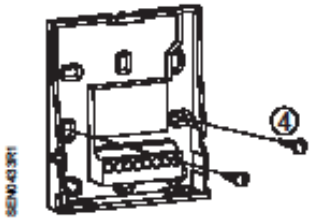

Figure 2.

5. Pull the wiring through the opening in the upper portion of the base.
6. Level the base and fasten it to the wall using two wood screws. The sensor is not position sensitive.
7. Pull the wiring through the base.
8. Position sensor housing over the two mounting lugs located at the top of the base and press down on cover until bottom lugs snap in place.
9. Terminate wires per wiring instructions on the inside of sensor cover.

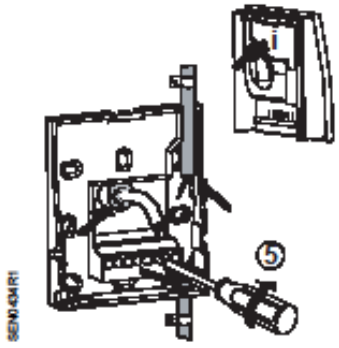

Figure 3.

10. Check that:
    a. The wires from the humidity sensing membrane are separated from each other and are not in contact with the PCA.
    b. The humidity sensing membrane has "free space" and is not in contact with the PCA or the temperature sensing element. See Figure 3.
11. Insert the top of the sensor cover into the slots located on the bottom of the sensor and press up until the locking tab snaps into place.

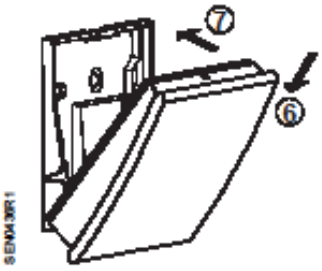

Figure 4.

The installation is now complete.

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2 × 4-inch Electrical Wall Box Mounting

An ARG70 wall plate adapter is required to mount a Q-Series CO_2 Room Sensor to a 2 × 4-inch electrical wall box. The ARG70 must be ordered separately.

1. Place a small screwdriver into the top of the sensor and press in the locking tab to remove the cover.
2. Using the two screws provided, fasten wall box adapter to plaster ring, supplied by others.
3. Flex adapter mask and snap in place inside wall box adapter.
4. Fasten sub-base, included with the Q-Series CO_2 Room Sensor, to wall box adapter assembly with the two screws provided.
5. Pull wires through plaster ring.
6. Follow *Drywall Mounting* Steps 6 through 11.

The installation is now complete.

Installing Temperature Sensing Elements (QPA2080 and QPA2080D Only)

QPA2080 and QPA2080D are shipped with four sensing elements: NTC 10K Ohm, Platinum 1000, Nickel 1000 and Platinum 100 (packaged separately).

Figure 5. Sensing Element Selections.

To install the sensing element of your choice:

1. Insert the element as shown in Figure 6.
2. Using a small, flat-blade screwdriver, tighten the sensor's two mounting screws.

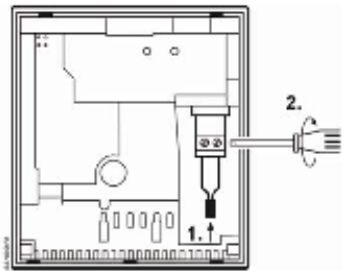

Figure 6. Installing the Sensing Element.

Commissioning

- The sensor's functions can be checked 30 minutes after applying power.
- Checking the CO_2 function:
  In well-ventilated rooms, the sensor shows the CO_2 concentration of the outside air. Typically, this is 360 ppm (depending on the sensor's measuring accuracy). Also, a basic functional check can be made by exhaling on the sensor. Note that the sensor's rate of response has been purposely delayed (time constant t_{90} = 5 minutes).
- Checking the VOC function:
  Touch the sensor with a cotton ball dowsed in alcohol.
- Ventilation should start when the preset switching level of the connected controller is reached.
- After applying power to sensors with display, **Init** will appear for about six seconds.
- See *QPA Series Indoor Air Quality Room Sensors Technical Instructions* (CE1N1961) for information on positioning the jumpers on the setting elements.

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Wiring Diagrams

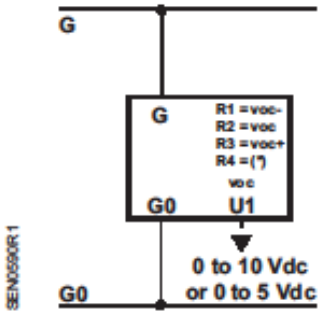

Figure 7. QPA1000.

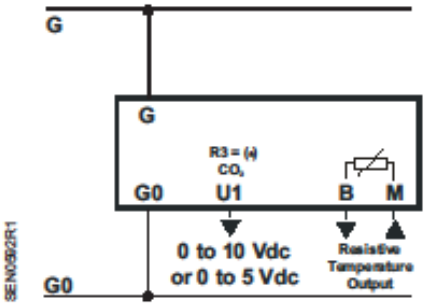

Figure 8. QPA2080, QPA2080D.

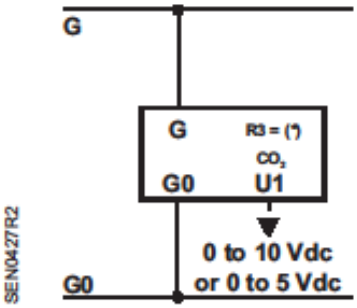

Figure 9. QPA2000 QPA2000N.

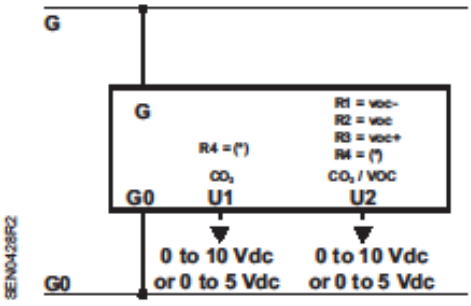

Figure 10. QPA2002, QPA2002D, QPA2002N.

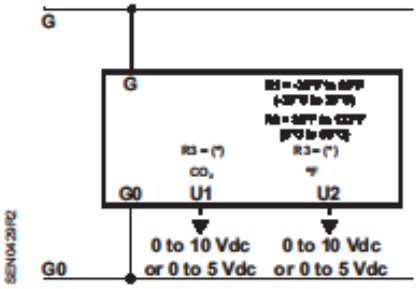

Figure 11. QPA2060, QPA2060D, QPA2060N.

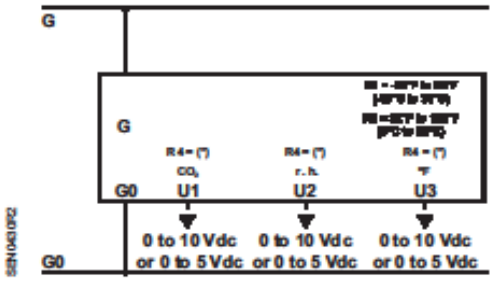

Figure 12. QPA2062, QPA2062D.

G, G0	System potential 24 Vac (SELV)	U3	Signal output 0 to 10 Vdc or 0 to 5 Vdc
G0	System neutral and measuring neutral	R..(*)	Signal output with R...= 0 to 10 Vdc;
U1	Signal output 0 to 10 Vdc or 0 to 5 Vdc		without R... = 0 to 5 Vdc
U2	Signal output 0 to 10 Vdc or 0 to 5 Vdc	B, M	Passive temperature output (interchangeable)

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8.10 Test Results

TEST TABLE

COMPONENT	SUB COMPONENT	TEST RESULTS	NOTES
DAMPER1	SIDE DMPR 1	POSITIVE	
DAMPER2	SIDE DMPR 2	POSITIVE	
DAMPER3	MID DMPR	POSITIVE	
QPA2000	CO2 LEVEL	POSITIVE	
	TEMPERATURE	NEGATIVE	NOT NECESSARY
QFA3171D	HUMIDITY	POSITIVE	
	TEMPRATURE	NEGATIVE	NOT NECESSARY
QAA2072	TEMP SENSE	POSITIVE	
	SETPOINT	NEGATIVE	SETPOINT NOT USED
540-680FB	TEMPERATURE	POSITIVE	
	SETPOINT	POSITIVE	
AIRVOLUME	SENSOR	POSITIVE	
ATEC DMPR		POSITIVE	
FIRE ALARM	PULL SWITCH	POSITIVE	
	LIGHTS	POSITIVE	
SWITCH	OCCUPANCY SENSOR	POSITIVE	
RELAY1	CURSENSE	POSITIVE	
RELAY2	LIGHTS	POSITIVE	
RELAY3	HEAT STRIP	POSITIVE	
HEAT STRIP		POSITIVE	
PXC CONTROLLER		POSITIVE	

SUBSYSTEM TESTING

ATEC SUBSYSTEM	AIRVOLUME	POSITIVE	
	HEAT STRIP	POSITIVE	
	TEMPERATURE	POSITIVE	
	SETPOINT	POSITIVE	
	PXC CONTROLL	POSITIVE	
AIRHANDLER MODEL	DMPR1	POSITIVE	
	DMPR2	POSITIVE	
	DMPR3	POSITIVE	
PXC CONTROLLER	THERMOSTAT	POSITIVE	
	AIR HUMIDITY SENSOR	POSITIVE	
	IAQ	POSITIVE	
	FIRE ALARM	POSITIVE	
NETWORKING	COMPUTER	POSITIVE	
	PXC CONTROLLER	POSITIVE	

8.11 Images of Final Design

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